ENGINEERING *FAMILIA*: THE ROLE OF A PROFESSIONAL ORGANIZATION
IN THE DEVELOPMENT OF
ENGINEERING IDENTITIES OF LATINA/O UNDERGRADUATES

BY

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DISSERTATION

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ABSTRACT

Despite the efforts that have been made in at least the last forty years, Latinas and Latinos continue to be underrepresented in engineering. Research has shown that students who identify as engineers during their college years are more likely to persist in engineering (Beam, Pierrakos, Constantz, Johri, & Anderson, 2009; Pierrakos, Beam, Constantz, Johri, & Anderson, 2009). One way to study identification with engineering is through a study of engineering identity development. The current literature on engineering identity has primarily focused on an aggregated population of engineering students, leaving the experiences of students of color unexplored (Matusovich, Barry, Meyers, Louis, 2011; Meyers, Ohland, Pawley, Silliman, & Smith, 2012; Tonso, 2006). This study aims to address this literature gap and the underrepresentation of Latina/o students by investigating their development of engineering identity.

In this study, I answered the following research question: In what ways and to what extent does membership in the Society of Hispanic Professional Engineers (SHPE) influence the engineering identity development of Latina/o students? The goal of this study was to produce a culturally situated understanding of the ways Latina/o students develop their engineering identities. To achieve this goal, I used a two-phase mixed methods design with a developmental purpose. Through this design, I conducted interviews and observations with Latina/o undergraduates using an asset-based and culturally situated approach guided by Yosso's (2005) Community Cultural Wealth Framework. Using results from the interviews and observations, I created and piloted a culturally situated survey of engineering identity development for Latina/o student members of SHPE.

This two-phase design revealed important and new dimensions of engineering identity development for Latina/o students. These new dimensions of engineering identity development were commitment to community, engineering role modeling, and nurturing an engineering *familia*. These dimensions build on and broaden current conceptualizations of engineering identity.

Keywords – Latinas, Latinos, Hispanic, engineering education, identity, underrepresentation, student organizations

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CHAPTER 1

Introduction

Reform of and changes in science, technology, engineering, and mathematics (STEM) education for all pre-college students has been a focus for the government at the state and federal levels, institutions of education, and the private sector in the United States. Many of the efforts addressing equity in STEM education today arose from the urgent need to address the underrepresentation of women and racial and ethnic minorities. Latinas and Latinos are part of the larger group of underrepresented racial and ethnic minorities in engineering. They remain a missing engineering potential as they have high aspirations to major in engineering (Gándara & Contreras, 2009). Aside from the institutional efforts in place to ensure the success of Latinas/os in engineering, understanding the way that Latinas/os develop their engineering identities in college should give insight into the ways that these students persist in college and the ways that institutions may be able to attract and retain more Latinas/os to the field. To understand the ways students develop an engineering identity, previous researchers have created engineering identity surveys that use measures of professional outcomes; however, these surveys are not culturally situated. To address this gap in the literature and the underrepresentation of Latina/o students in engineering, I employed a mixed methods approach to develop a culturally situated survey of engineering identity based on the experiences of Latina/o undergraduate engineering students.

Since at least the 1970s, efforts have been made to increase the number of underrepresented minorities and women in STEM fields in the United States. In 1987, the Higher Education Research Institute (HERI) published a report on American freshmen from 1966 to 1985, based on national survey data collected from freshmen at two-year and four-year colleges and universities in the United States (Astin, Green, & Korn, 1987). While there was an overall decline of students' interest in "virtually every field that has traditionally been associated with a liberal arts education" (p. 15), there was a momentary peak of student interest in engineering from 1974 to1983. As the concern in the decline of students' interest in engineering grew, the problem of underrepresentation of African Americans, Latinas/os, and Native Americans in science and engineering also grew. In 1986, the National Science Foundation (NSF) released the *Neal Report*, which highlighted the flaws in laboratory instruction, curriculum, and teaching at the undergraduate level in the sciences (Seymour & Hewitt, 1997). According to Seymour and Hewitt, the HERI and NSF reports in the 1980s and many others agreed on three findings:

> Science and mathematics education was failing to foster science literacy in the population; too few undergraduates and graduates were recruited and retained to meet the nation's future needs; and the sciences recruited too exclusively among white males – thereby depriving the nation of the talents of women of all races and ethnicities, and men of color (p. 1).

As a result of these reports on the deficiencies with mathematics and science education at the K-12 and college level, policy and programmatic efforts grew in the late 1980s and 1990s. Many studies investigated the issue of underrepresentation of women, racial, and ethnic minorities in science and engineering (as reviewed in Leslie and Oxaca, 1997). Additionally, in 1996 the National Science Education Standards were edited to address science literacy in the United States:

> The National Science Education Standards are premised on a conviction that all students deserve and must have the opportunity to become scientifically literate. The Standards look toward a future in which all Americans, familiar with basic scientific ideas and

> processes, can have fuller and more productive lives. This is a vision of great hope and optimism for America, one that can act as a powerful unifying force in our society. We are excited and hopeful about the difference that the Standards will make in the lives of individuals and the vitality of the nation (National Research Council, 1996, p. IX).

In part, the focus on K-12 science standards emerged from the realization that underrepresentation of women and racial and ethnic minorities in STEM must be addressed along all segments of the educational "pipeline" (coined by Berryman, 1983). In fact Seymour and Hewitt's (1997) seminal study on why students leave science, mathematics, and engineering (SME) majors was partly aimed at understanding the leaky pipeline issue – the idea that even when some students switched into SME majors and some switched out, there was an overall net loss of students majoring in SME. Seymour and Hewitt found that those students who left and those who stayed were not "two different kinds of people" (p. 30). Switchers and non-switchers shared many of the same qualities and voiced many of the same problems they encountered in their SME education.

Even though the policies and programs implemented in the 1990s to address equity in STEM education led to an increased number of underrepresented students achieving STEM degrees, overall disparities remain today at a level disaggregated by discipline. From 2000 to 2008, women have earned around 50% of bachelor's degrees in science and engineering disciplines in the United States (NCSES, 2011). In math and computer science and in engineering, however, women's achievement is below parity. In fact in 2008 women earned 25.3% and 18.5% of these bachelor's degrees respectively. Compared with the physical and social sciences, engineering has the lowest percentage of bachelor's degree achievement by women. Moreover, even though the percentage of engineering bachelor's degrees received by women increased, from 0.4% in 1966 to 18.5% in 2008 (Hill, Corbett, & St. Rose, 2010), in the last 10 years that percentage has actually decreased from its peak of 20.9% in 2002 and has remained stagnant (NCSES, 2011). A similar trend in the decline of bachelor's degree attainment occurred in computer science for women, with a peak of 35.8% in 1986 (Hill, Corbett, & St. Rose, 2010). George-Jackson (2011) found that women in agricultural and biological sciences, health sciences, and psychology persist at a higher rate than men.

There are differences of achievement when data are disaggregated not only at the discipline and field level, but also at intersections of race, gender, and ethnicity. For example, the bachelor's degree achievement in science and engineering for African Americans, Asian and Pacific Island Americans, Latinas/os, and Native Americans as a group has increased from 23% in 1997 to 26% in 2006. However at a disaggregated level, there exist disparities; for example, the number of bachelor's degrees attained by African Americans in engineering has leveled off at around 3,000 (4.57%) as of 2010 (NACME, 2010). Even though I have highlighted bachelor's degree achievement for underrepresented minorities in science and engineering, the trends are similar if not more pronounced for master's and doctoral achievement. As summarized in the 2010 brief by the National Action Council for Minorities in Engineering, the percentage of degrees achieved by African Americans, Native Americans, and Latinas/os decreases as the level of achievement (i.e., bachelor's, master's, doctoral) increases. These inequities in undergraduate level achievement translate to graduate education in STEM, industry and the workforce, academia and other places where underrepresentation of racial and ethnic minorities and women persists today.

Analyzing and understanding experiences disaggregated by discipline, race, ethnicity, and gender also highlights the importance of individual diversity, that is "the breadth of experience within a single individual" (Foor, Walden, & Trytten, 2007, p. 103). Aside from understanding experience at the intersections of gender, race, and ethnicity, there are other ways in which students are underrepresented such as being a first-generation student, low-income student, or multi-minority student (Foor, Walden, & Trytten). A student who falls into one or more of these categories may be

> a student who comes from an economically disadvantaged background outside the dominant culture and who attended a resource-poor high school does not have the same odds of contributing to the gene pool in engineering as a student from a family within the dominant culture of median or above median means, and attended a resource- rich school district. Because of this, engineering suffers the loss of individual diversity (Foor, Walden, & Trytten, 2007, p. 103).

The grouping of women and racial and ethnic minorities in STEM research may lead to a loss of understanding diversity within the larger group of underrepresented minority students.

The goal to achieve equity in STEM education is often accompanied by an economic justification that having more women and racial and ethnic minorities in science and engineering will lead to greater economic productivity (Hill, Corbett, & St. Rose, 2010; Leslie, McClure, & Oaxaca, 1998). Part of this argument is rooted in the idea that if women and racial and ethnic minorities are underrepresented in STEM, then, as a society, we are missing on a talented pool of scientists and engineers and a loss of human capital (National Research Council, 2007). The human capital argument was revisited in the 2011 report from the national academies on *Expanding Underrepresented Minority Participation*. To achieve the goal of maintaining global competitiveness in science and engineering proposed in *Rising Above the Gathering Storm* (National Research Council, 2007), the 2011 report argues that

> the United States stands again at the crossroads: A national effort to sustain and strengthen [science and engineering] must also include a strategy for ensuring that we draw on the minds and talents of all Americans, including minorities who are underrepresented in [science and engineering] and currently embody a vastly underused resource and a lost opportunity for meeting our nation's technology needs. (National Academy of Sciences, Global Affairs, & Institute of Medicine, 2011, p. 2)

Part of the economic argument is strengthened by the projected change in population demographics in the United States – that is, that traditionally underrepresented minorities in science and engineering are projected to represent one-half of the population by 2060 (U.S. Census Bureau, 2012).

As a justification to achieve greater representation for women and racial and ethnic minorities in science and engineering, scholars have also presented a social justice argument. For example, Adams et al. (2011) report a conversation among scholars in engineering education representing various educational backgrounds including psychology, mathematics, educational psychology, science, and engineering. Part of the conclusion from this conversation is that educators must work to emphasize social justice for engaging future engineers. In Adams et al., Martin summarizes the social justice stance:

> I am dedicated to equity of access and participation by all people in the educational and career opportunities that engineering can provide. In other words, because of social justice. There are whole groups of people who have historically been excluded from the individual economic prosperity that a STEM career can provide. We may have lost focus on helping underrepresented groups achieve individual prosperity by focusing on national prosperity (p. 71).

Whether efforts and research are fueled by the social justice or the economic argument, encouraging more students to enroll in a STEM field at the post-secondary level continues to be a key focus of the government today (Feder, 2012). In *Rising Above the Gathering Storm*, a goal was set to increase the percentage of 24 years old with a natural sciences or engineering degree to ten percent. As scholars have pointed out, however, the task of increasing representation of women and underrepresented students in STEM is difficult because “these students now need to triple, quadruple, or even quintuple their proportions with a first degree in these fields in order to achieve this 10 percent goal” (National Academy of Sciences, Global Affairs, & Institute of Medicine, 2011, p. 35).

This study seeks to address the issue of underrepresentation and success of Latina/o undergraduates in engineering using an asset-based approach by investigating the experiences of self-identified Latina/o undergraduate student members of the Society of Hispanic Professional Engineers (SHPE), the largest organizations for Latinas/os in engineering and a key resource for students during college.

Statement of the Problem

The forecasted growth of Latinas/os in the United States has encouraged a range of institutions to reassess how this shift in population will affect various programs of study, especially those in science, technology, engineering, and mathematics (STEM) where Latinas/os are currently underrepresented. Despite efforts in the last 40 years to increase participation of Latinas/os in engineering, Latinas/os remain underrepresented. In the United States, the percentage of Latina/o students enrolling in engineering majors has increased since the 1990s and it is projected to continue to increase. Engineering is one program of note because it is the second most chosen career path by Latinas/os in the sciences, and one that many Latina/o students denote as prestigious or synonymous to being called a doctor (Camacho & Lord, 2011). In this study, I will address the following research question: In what ways and to what extent does membership in the Society of Hispanic Professional Engineers influence the engineering identity development of Latina and Latino students?

CHAPTER 2

Literature Review and Conceptual Frameworks

This literature review shows the need for studies of engineering identity development of Latina/o students. Also, this literature review provides an overview of the educational journeys for Latina/o students in the United States with a focus on engineering. This literature review is divided in the following subsections: Latinas/os in the United States, Latinas/os in K-12 Education, Latinas/os in Higher Education, Latinas/os in STEM, Latinas/os in engineering, Involvement in Student Organizations, and Theoretical and Conceptual Frameworks.

Latinas/os in the United States

Latinas/os are a growing minority in the United States. Though the Latina/o population comprises an estimated 16.7% of the overall national population, the percentage of Latina/o youth and children is much larger (Chapa & De La Rosa, 2006): Latina/o children between the ages of five and fourteen years old in the United States represent roughly 22% of all children between these ages (U.S. Census, n.d.). In addition, much of this population increase is projected to be caused by immigration, because in the past, immigration has contributed significantly to population increase in the United States. As a consequence, the Pew Research Center estimates that Latinas/os will represent around 29% of the population by 2050 (Pew Research Center, 2008).

According to Gándara and Contreras (2009), the majority of Latinas and Latinos in the United States live in low-economic conditions, with limited or no access to health care, and they attend underfunded and segregated schools. In fact, the poverty rate among Latina/o children is three times that of White children. The living conditions play an important role in a child’s educational development. There is an achievement gap between Latinas/os and their White and

Asian peers before Latinas/os children start formal schooling (Gándara, 2006). Impoverished living conditions and inadequate educational opportunities reduce the college readiness of Latinas/os.

Among Latina/o racial/ethnic groups, there are differences in educational achievement and college aspirations and expectations. These differences show the varying educational experiences that exist in the often-aggregated Latina/o racial/ethnic group. Among the five largest Latina/o racial/ethnic groups in the United States, Cubans fare the best in terms of achievement in education compared with Puerto Ricans and Chicanas/os (Solórzano, Villalpando, & Oseguera, 2005). With regard to college aspirations and expectations, although all Latina/o groups have high college aspirations and expectations, there are differences across groups. Mexican and Puerto Rican youth are more likely to have weaker college aspirations and expectations than non-Latino White youth. In contrast, Cuban youth are more likely to have stronger college aspirations and expectations than non-Latino White youth (Bohon, Johnson, & Gorman, 2006).

Latinas/os in K-12 Education

Latina/o students are less academically prepared than White students for high school and for college (Nora & Crisp, 2009). As an example, Latinas/os substantially underperformed in elementary and secondary math and science courses compared to their White and Asian peers. Gándara (2006) argues that because of the current educational achievement gap between Latina/o students and their White and Asian American peers in the United States, we would need to invest 1.5 to 2 times as much as we do now per pupil with early intervention programs.

With regards to high school, Latina/o students dropout at a higher rate (15.1% in 2010) than African American and White students (NCES, n.d.). Compared to their White and Asian peers, Latinas/os are more likely to attend a high school with lower quality teachers who have low expectations for their success (Gándara & Contreras, 2009). Latinas/os are underrepresented in AP courses and college-prep courses. In fact, Latinas/os make up only 8% of calculus BC and 7% of physics C AP exam takers (National Science Board, 2014).

Latinas/os in Higher Education

As depicted in Yosso (2006) and Solórzano, Villalpando, and Oseguera (2005), of 100 Latinas/os who start elementary school, only 52 of those 100 students graduate from high school, and 10 graduate from college. In fact, Solórzano, Villalpando, and Oseguera (2005) show that at any point in the educational pipeline, Latinas/os do not perform as well as other students. The likelihood that a Latina/o student will attend college and graduate from college is lower than their peers. As a result researchers have reframed the educational pipeline for Latinas and Latinos as more of a pipette, where only a few make it out at the other end, or a leaky pipeline, where students leave throughout the pipeline (Chapa & De La Rosa, 2006).

The percentage of Latina/o high school graduates who enroll in college is low. Fourteen percent of all students enrolled in college for the fall of 2010 were Latinas/os. Over half of these students (50.6%) enrolled in 2-year public colleges (NCES, n.d. b). Latinas/os are overrepresented in 2-year or community colleges. While enrollment in community colleges can lead to transfer to a 4-year institution and bachelor's degree attainment, "when Latinas/os begin their postsecondary education at a 2- year community college, in contrast to beginning at a 4-year institution, they face a greater possibility of not completing a baccalaureate degree" (Solórzano, Villalpando, & Oseguera, 2005, p. 282). The lack of transfer culture in 2-year community colleges contributes to the low transfer rates for Latina/o college students (Solórzano, Villalpando, & Oseguera).

According to the Pew Hispanic Center (2002), Latinas/os also have low college completion rates. The low completion rates may be attributed to the large number of Latinas/os who enroll in two-year colleges because Latinas/os who enroll in two-year colleges are less likely to complete their college degree than those students who enroll in four-year colleges (Pew Hispanic Center, 2002). Among the college graduates in the 2009-2010 academic year, 13.7% of associate degree graduates were Latinas/os and 8.8% of bachelor degree graduates were Latinas/os (U.S. Department of Education, 2012). Although Latinas/os have lower completion rates than their non-Latina/o peers, there is an upward trend of college completion among Latinas/os. In 1977, Latinas/os earned 2.1% of the bachelor's degrees in the United States and in 2012 they earned 9.8% of the bachelor's degrees. Of those bachelor's degrees conferred by a postsecondary institution to Latinas/os in the 2011-2012 academic year, the majority (20.25%) were in the field of business, followed by social sciences (9.77%) and psychology (7.86%). Compared with their African American, Asian American, and White peers, Latinas/os have the lowest rate of graduate school enrollment.

Because the majority of Latina/o students enroll in 2-year colleges, it is not surprising that the majority of Hispanic Serving Institutions (HSIs) are community colleges. Per Title V, eligible higher education institutions can apply for a program that "provides grants to assist HSIs to expand educational opportunities for, and improve the attainment of, Hispanic students. The HSI program enables HSIs to expand and enhance their academic offerings, program quality, and institutional stability" (U.S. Department of Education, n.d.). An institution can apply to become an HSI as long as it meets at least the following three criteria: (1) accredited and non-profit, (2) at least 25% Latina/o student full-time enrollment, and (3) at least 50% of Latinos are low-income students. Yet, some HSIs do not have equitable outcomes for all students and they have lower degree attainment outcomes for Latinas/os than their White counterparts (Contreras, Malcom, & Bensimon, 2008). Santiago, Andrade and Brown (2004) argue that apart from meeting these criteria, HSIs should serve their Latina/o student population in a more meaningful way.

The majority of Latina/o college students are low-income (Santiago, Andrade, & Brown, 2004; Solórzano, Villalpando, Oseguera, 2005), first-generation students (Santiago, Andrade, & Brown, 2004), and concentrated primarily in the southwest and western part of the United States. Another factor of consideration for Latina/o students is undocumented status. As cited in Nora & Crisp (2009), about 80% of the ten million undocumented people in the United States are of Hispanic origin. Further, Perez (2009) reported that around two-thirds of undocumented students who graduate from high school are Latinas/os.

Although commonly studied as an aggregate group, Latinas/os are not a monolithic group and there are some important characteristics to consider when studying this population. Some of these characteristics include race, ethnicity, nationality, generational status, and native languages.

Various cultural, institutional, environmental, and psychosocial factors influence Latinas/os who persist and graduate with a baccalaureate degree. Nora and Crisp (2009) identified some of these important factors that influence retention of Latinas/os students in higher education. Some cultural and background factors can improve persistence of Latina/o students. These cultural and background factors include encouragement and support from family, high college expectations, student’s self-aspirations and educational goals, leadership experiences before college, and quality of pre-college education. Yet other cultural and background factors can reduce the persistence of Latina/o students in college including limited

English proficiency, being raised in a single parent home, and quality of pre-college education. Institutional factors also matter in the way that Latinas/os persist in college. These factors include financial assistance, access to meaningful mentoring relationships, and opportunities to work on campus. Latina/o students' perception of climate also matters for their persistence. Students are more likely to continue enrollment in institutions where Latina/o perceive their institutions as ethnically diverse. Additionally, students who have a sense of belonging, are engaged on campus (e.g., joining a student organization of interest), experience academic integration, and perceive positive academic performance are more likely to persist in higher education.

Latinas/os in STEM

Within higher education, there are unique problems in the STEM fields that Latina/o students face. Pre-college preparation in math and science at the K-12 level affects students' success in STEM (National Academies, 2011; National Science Foundation, 2009). As explained by Conley (2010), a student who is eligible for college might not be ready for college. However, a college-eligible or even a college-ready student might not be a STEM-ready student. For example, a student may be college-eligible by the general college admission standards, but perhaps not STEM-ready because he or she did not complete the math courses necessary to be accepted into a STEM field without remedial education. A strong pre-college preparation in the K-12 curriculum would allow a student who wishes to pursue a career in STEM to be college-ready and STEM-ready.

To ensure that students are STEM-ready, national agencies have reported on the state of STEM fields in the United States. In the national report *Rising Above the Gathering Storm*, the following questions were posed about the state of STEM,

> What are the top 10 actions, in priority order, that federal policymakers could take to enhance the science and technology enterprise so that the United States can successfully compete, prosper, and be secure in the global community of the 21st century? What strategy, with several concrete steps, could be used to implement each of those actions? (National Research Council, 2007, p. xi)

A committee of university presidents, CEOs, Nobel laureates, and former presidential appointees answered with four main strategies to maintain the United States as a global competitor in science and technology. These strategies included strengthening K-12 education and broadening the STEM pipeline. In a follow-up report from the National Academies, *Expanding Underrepresented Minority Participation*, a committee further highlighted the importance of focusing on change that addresses the demographic changes in the United States.

> The United States stands again at the crossroads: A national effort to sustain and strengthen [science and engineering] must also include a strategy for ensuring that we draw on the minds and talents of all Americans, including minorities who are underrepresented in [science and engineering] and currently embody a vastly underused resource and a lost opportunity for meeting our nation's technology needs. (National Academy of Sciences, Global Affairs, & Institute of Medicine, 2011, p. 2)

This report concludes that broadening participation of traditionally underrepresented groups in science and engineering should play a central role in addressing the nation's research and innovation capacity. The two top priority, short-term action items were highlighted in this report. The first priority action item includes policies and programs that address minority retention and completion through academic, social, and financial support. Financial support was highlighted as an important short-term action item to address retention and completion. The second priority action item includes teacher preparation programs, college preparation programs, and an emphasis on STEM graduate school. Both reports, *Rising Above the Gathering Storm* and *Expanding Underrepresented Minority Participation*, highlight the continued focus on broadening participation in STEM by increasing the number of people in underrepresented groups.

Students' perceptions of themselves as being part of STEM education or pursuing a STEM-related career are rooted in the students' self-concept towards math and science. For example, elementary school level girls and boys take about the same number math and science courses (Hill, Corbett, & St. Rose, 2010), yet fewer girls pursue STEM majors. The disparity could be caused by the way they shape (or not) their self-concept towards math and science because of their environment. According to Leslie et al. (1998) "boys over estimate their abilities [in math and science]; girls underestimate theirs" (p. 255) even when both boys and girls have the same kind of achievement in math and science. The barrier then is that underrepresented students, or perhaps specifically women of color, in STEM may not have the self-concept towards math and science to choose STEM postsecondary majors. Developing such a self-concept towards math and science outside of the classroom may be even more difficult if the students don't have role models in STEM (Fernandez et al., 2008) or access to a cultural capital that sparks their interest and knowledge of STEM fields (Chanderbhan-Forde, Heppner, & Borman, 2012). The American Association of University Women (2010) reported that girls are more likely to say they will study STEM if they are encouraged by their parents and teachers and reminded that their "intelligence can expand with experience and learning" (Hill, Corbett, & St. Rose, p. xiv). As cited in Hoffman, St. Louis, and Hoffman (2010), "having a parent employed in science is an important factor for all students who express an interest in a college science major" (p. 240). That said, because of the historical underrepresentation of women and racial and ethnic minorities in STEM, a parent who is a scientist or an engineer may not be a reality for these students.

Over the last forty years, programmatic interventions at the higher education level have addressed the issue of underrepresentation of racial and ethnic minorities in STEM fields with effects mainly on retention (Tsui, 2007). With regard to retention, Seymour and Hewitt (1997) found that students who stay in science, engineering, and mathematics (SEM) disciplines are not much different academically from students who leave SEM disciplines. Some students who leave describe an unwelcoming environment or a "chilly climate." The chilly climate and the experiences of all STEM students may not be equal, however, and there are urgent calls for the need to disaggregate data and study the nuances of experiences by field of study as well as by looking at intersections of race, gender, and ethnicity (George-Jackson, 2011; Lord et al., 2009; Camacho & Lord, 2013).

Not many studies have investigated the experiences of students in STEM disaggregated by race or ethnicity. Furthermore, the literature on the experiences of Latinas/os in STEM is often aggregated with that of other students. However, there are few studies that provide an insight about the Latina/o experience with STEM majors. For example, Camacho and Lord (2011) found that the second most popular major in STEM for Latino males is engineering. With regard to success, high school preparation was found as an important indicator of success in science, engineering, and math (Bonous-Hammarth, 2000; Brown, 2002; Cole & Espinoza, 2008). May and Chubin (2003) found that Latina/o students in STEM may face unique barriers. These barriers include facing a chilly climate, lacking a strong college preparation, and feeling a sense of belonging in STEM (May & Chubin, 2003). Some of the climate barriers may be alleviated at Hispanic Serving Institutions (HSIs) where Latinas/os are well represented among STEM majors at HSIs. In fact, "Hispanic ethnicity was found to increase the odds of declaring a major in a STEM at the HSI" (Crisp, Nora, & Taggart, 2009, p. 939). Literature about Latina/o students in STEM needs to be desegregated for a better understanding of the student experience.

Latinas/os in Engineering

Within STEM, engineering is an important major of note for Latinas/os. Latina/o students have high aspirations for majoring in engineering compared to other underrepresented groups (Gándara & Contreras, 2009). In fact, engineering is the second most popular field of study among sciences and engineering for Latinos (Camacho & Lord, 2011). Furthermore, Latinas/os express the prestige of being an engineer to that of being a doctor.

Latinas/os have had an upward enrollment trend in engineering since the early 2000s. In the last 20 years, 10% of students enrolled in engineering in the United States were Latina/o (NSF, 2013). Of Latina/o bachelor's degree recipients in the 2011-2012 academic year, 4.3% of them earned an engineering degree. A fraction of Latina/o students earns engineering degrees from high-Hispanic enrollment institutions. In 2013, about 37% of bachelor's in engineering degrees awarded to Latinas/os come from high-Hispanic enrollment institutions (NSF, 2013). Camacho and Lord (2011) argue that Hispanic Serving Institutions may serve as role model institutions for graduating Latinas/os in engineering.

Some of the factors that contribute to success of Latinas/os in engineering include self-concept/self-efficacy (Leslie, McClure, Oaxaca, 1998; Camacho & Lord, 2013; Ong, Wright, Espinosa, & Orfield, 2011), pre-college educational experience and preparation (Brown, 2002; Cole & Espinoza, 2008), family (Brown, 2002), a welcoming campus culture (Museus & Liverman, 2010), positive interactions with faculty including mentoring relationships (Cole &

Espinoza, 2008; Griffin, Pérez, Holmes, & Mayo, 2010; Trenor, Yu, Waight, Zerda, & Sha, 2008), and involvement in summer programs including research and academic enrichment programs (Brown, 2002; Johnson, 2007; Tsui, 2007). Latinas/os students who have parents with engineering degrees are more likely than Latina/o students who do not have parents with engineering degrees to matriculate into engineering and choose an engineering career (Leslie, McClure, Oaxaca, 1998); however, the majority of parents of Latina/o engineering students have only a high school education (Cole & Espinoza, 2008; Tsui, 2007).

In addition to these factors that contribute to the success of Latinas/os in engineering, May & Chubin (2003) emphasize the importance of policies and institutional factors. They argue for the importance of affirmative action, minority serving institutions, 2-year colleges, and dual degree programs in enrollment and retention of engineering underrepresented students. But more importantly, May and Chubin argue that the media image of an engineer is generally that of a white male:

> One reason that minority children don't think of engineering as a career to which they can aspire is that people who look like them are so seldom portrayed as engineers or scientists, making recruitment of minority students into engineering fields all the more challenging. (p. 32)

Minority Engineering Programs (MEPs) modeled after the California minority engineering program have also been key in the success and retention of underrepresented students in engineering. The MEP programs often address aspects of academic, social, and professional development for students with a focus on academics (May & Chubin, 2003; Tsui, 2007). According to May and Chubin (2003), part of the success behind MEPs is the use of collaborative learning to structure the MEP student experience. Collaborative learning and the

MEP goals are achieved through freshman orientation, clustering groups of students in the same courses, study center, and structured study groups. As a result of these efforts, the students who participate in MEPs are more likely to be retained in engineering than students who do not participate in MEPs. However, interestingly, although participation in MEP addresses retention, it does not account for an increase in GPA (Good, Halpin, & Halpin, 2002).

Knowledge and resources about college are part of the way that students make choices and aspire to go to college. In fact, as highlighted by Cabrera and La Nasa (2000) the college-choice process includes factors such as high school academic resources and parental collegiate experience; the college-choice process leads to outcomes of college awareness and an application to college. This process spans over many years with predispositions about college in grades 7-9, college search in grades 10-12, and college choice in grades 11-12. Lack of knowledge and resources about college and engineering explain why students do not pursue careers in engineering. Brown (2002) found that Latina/o students who were successful in science and engineering at the college-level had strong familial support, but also had access to honor programs and a strong and interactive high school curriculum. Similarly, Moore (2009) found that strong familial support and access to enrichment programs and opportunities in high school led to African American male student success in engineering.

Even when students have strong familial support and opportunities in their high schools, they may still not have the knowledge and resources that can make the transition to college easier or possible. For example, in their study of first-generation engineering students, Fernandez, Martin Trenor, Zerda, & Cortes (2008) found barriers that students perceived in their education, these barriers were connected to a lack of knowledge and/or resources such as lack of understanding the admission process for college and lack of understanding of the financial aid process for college. Creating a college-going culture for students might be crucial in addressing the lack of knowledge and resources. A college culture "in a high school cultivates aspirations and behaviors conducive to preparing for, applying to and enrolling in college. A strong college culture is tangible, pervasive and beneficial to students" (Corwin & Tierney, 2007, p. 3). The role of creating a college-going culture is not only a responsibility of the parents and teachers, but also school staff and community members.

Involvement in Student Organizations

Social and extracurricular involvement in college can influence several aspects of students' lives. In their comprehensive review of literature, Pascarella and Terenzini (2005) found that "extracurricular involvement had modest, positive effects on institutional persistence and educational attainment, women's choice of non-traditional careers, and development of a positive social self-concept" (p. 616). However, the majority of research to study these influences has focused on Greek affiliation and athletic participation. As argued more recently by Harper and Quaye (2009), the onus of engagement must be shifted from students to administrators and educators. This shift is critical in continuing our understanding of purposeful engagement and involvement in college. In fact, Rendon (1994) argues that for non-traditional students, involvement goes beyond the student's initiative, time, and effort to be involved. Instead, a non-traditional student would consider being involved not just when the student reaches out to an educator (e.g., faculty member, adviser) for help, but also when an educator reaches out to the student.

Involvement in student organizations can help with success and persistence of students of color in college (Fischer, 2007). However, the type of organization matters when looking at different types of effects, especially for Latinas and Latinos (Baker, 2008). Involvement in political organizations has a positive effect on academic performance of Latinas and Latinos in college (Baker, 2008). Other benefits of being involved in political organizations include an increased self-concept and sense of empowerment. On the other hand, involvement in athletics has a negative effect on academic performance for Latinas. Involvement in fraternities and sororities has negative effects on both Latinas and Latinos. Latina/o students who are active in social-community and religious organizations have a greater sense of belonging in college than those who are less active (Hurtado & Carter, 1997). Harper and Quaye (2009) show that involvement in ethnic student organizations has an influence on Black identity development of African American students. Moreover, participation in ethnic organizations helps with social integration and success of students of color especially at predominantly white institutions (Guiffrida, 2003).

Consistent with the higher education literature on student involvement, engineering students who are part of engineering student organizations are more likely to identify as engineers and commit to an engineering career than students who are not part of these organizations (Hughes & Hurtado, 2013). With regard to identity development, Martin, Simmons, and Yu (2013) report on the experiences of four Hispanic women majoring in engineering, who are first-generation or whose parents attended some college but did not finish. These women's identities as engineers were reinforced through membership in student organizations. The research on student organizations and how these influence professional identity development of students of color is limited. Results on how student organizations could be helpful for students' identity development warrant further study.

Engineering Identity

Research has shown that students who identify as engineers during their college years are more likely to persist in engineering (Beam, Pierrakos, Constantz, Johri, & Anderson, 2009; Pierrakos, Beam, Constantz, Johri, & Anderson, 2009). Although research on science and engineering identity is still growing, there are frameworks that capture some of the ways that students identify as engineers. In the science identity model developed by Carlone and Johnson (2007), the authors highlight *recognition* as an important dimension for science identity. *Recognition* by self and by others is an important aspect of someone's identity as a scientist. Tonso's (2006) work on engineering identity describes identifying as an engineer as finding a sense of belonging within the engineering culture. Stevens, O'Connor, Garrison, Jocuns, and Amons (2008) present an analytic framework on how students become engineers based on a longitudinal ethnographic inquiry. Their framework consists of three dimensions: *disciplinary knowledge*, *identification*, and *navigation*. *Disciplinary knowledge* refers to the traditional engineering specific knowledge that students learn whilst earning their engineering degree. *Identification* refers to how students identify as engineers and how they are identified by others as engineers. Finally, *navigation* refers to the official and unofficial ways that students navigate their personal and professional pathways to an engineering degree. Stevens et al. found that identification with and by others in engineering was an important aspect of becoming an engineer.

There are tangible and intangible factors that students use to identify as engineers. Loui (2005) found that students called themselves engineers after they received their engineering diploma. Meyers, Ohland, Pawley, Silliman, and Smith (2012) found intangible factors that students use to identify as engineers such as "making competent design decisions, working with others to share ideas and accepting responsibility." Being called an engineer by faculty can aid with early identification as an engineer (Meyers et al., 2012). Meyers et al. also found that women are less likely than men to identify as engineers, especially freshmen female students.

At minority serving institutions, African American and Latina/o students' identity development is shaped by the positive experiences with faculty and peers in the programs (Fleming, Smith, Williams, & Bliss, 2013). In identifying as engineers, students express a certain pride in the rite of passage of overcoming the challenges of the engineering curriculum and thus identifying as engineers (Flemming et al., 2013; Matusovich, Barry, Meyers, & Louis, 2011).

Theoretical and Conceptual Frameworks

This study was primarily guided by the Community Cultural Wealth (CCW) framework by Yosso (2005). Two other frameworks guided the design of this study, but not the analysis of the data. These frameworks are the model of multiple dimensions of identity (Abes, Jones, & McEwen, 2007), and intersectionality (Collins, 2002; Crenshaw, 1991).

Community Cultural Wealth. Yosso's (2005) Community Cultural Wealth (CCW) theoretical framework originates in critical race theory (CRT). CRT grew out of the field of critical legal studies, which was a response by legal scholars to the legal and social injustices that oppressed people suffered. Alan Freeman, David Trubeck, and Derrick Bell extended the critical legal studies to include race as the primary and central focus of their scholarly inquiry. In 1989, Kimberle Crenshaw and colleagues followed up with a workshop on critical legal studies and the issues of race, which they titled critical race theory (Ladson-Billings, 2009). CRT scholars (Delgado Bernal, 2002; Dixson & Rousseau, 2005; Solórzano, 1998; Tate, 1997) have since applied the tenets of CRT to the field of education; Solórzano (1998) presents the five tenets of CRT as these apply to education,

1. The centrality and intersectionality of race and racism – race is central and race and

racism intersect with class, gender, and other forms of subordination.

2. The challenge to dominant ideology – challenges educational institutions to objectivity, meritocracy, color and gender blindness, race and gender neutrality, and equal opportunity
3. The commitment to social justice – commitment to social justice and elimination of racism
4. The centrality of experiential knowledge – recognition that that the experiential knowledge of women and men of color is legitimate, appropriate, and critical to understanding, analyzing, and teaching about racial subordination in the field of education
5. The interdisciplinary perspective - insists on analyzing race and racism in education by placing them in both a historical and contemporary context using interdisciplinary methods

With the tenet of the centrality of experiential knowledge, CRT "recognizes that the experiential knowledge of women and men of color is legitimate, appropriate, and critical to understanding, analyzing, and teaching about racial subordination in the field of education" (p. 122). An example of application of the centrality of experiential knowledge is in valuing the lived experiences of people of color through appropriate inquiry (Delgado Bernal, 2002; Ladson-Billings, 2009).

The CCW framework was created to study and acknowledge the wealth in the lived experience of students of color. This framework posits six forms of capital: aspirational, linguistic, familial, social, navigational, and resistant. Aspirational capital "refers to the ability to maintain hopes and dreams" even in the face of barriers. Linguistic capital "includes the intellectual and social skills attained through communication experiences in more than one language and/or style." Familial capital "refers to those cultural knowledges nurtured among *familia* (kin) that carry a sense of community history, memory and cultural intuition." Familial capital also "engages a commitment to community well being." Social capital refers to the "networks of people and community of resources." Navigational capital "refers to skills of maneuvering through social institutions." Resistant capital "refers those knowledges and skills fostered through oppositional behavior that challenges inequality." Yosso argues that Bourdieu's work about social capital has been used to justify why students of color lack capital. As a result and as a critique of that deficit thinking, the CCW framework highlights the importance of understanding communities of students of color from an asset-based approach rather than a deficit model. This framework enables researchers to identify and document wealth "to transform education and empower People of Color to utilize assets already abundant in their communities" (p. 89).

Through the use of the CCW framework, I am able to investigate the Latina/o engineering student experience by focusing on the knowledges these students bring to their engineering programs and schools rather than focusing on deficiencies. In his study of Latino *logradores* (achievers) at a predominantly White institution, Pérez (2012) found that students conceptualized their achievement not by using "traditional" measures such as grades, but in other ways that highlighted aspirational, resistant, familial, social, navigational, and linguistic capital. In their words, students conceptualized achievement as being the best, being well-rounded, and being involved, all of which were captured through the use of the CCW framework. In their survey of Latinas/os in STEM fields, Baber, Rincon, and Martinez (2012) found that students drew wealth from outside of the university. Additionally, they found that students employed their navigational capital and sought out organizations that targeted underrepresented populations as a way of persisting in STEM. Similarly, the use of CCW allows me to explore the students' experiences and engineering identity development from an asset-based framework.

Model of Multiple Dimensions of Identity and Intersectionality. Because people are not one dimensional, various identities may be salient at different times. Researchers have investigated the construct of engineering identity using multiple identities framework (Pierrakos et al., 2009; Tate & Linn, 2005); however, these investigations have not been focused on the purposeful investigation of intersections between social identities and engineering identities for underrepresented students. To address that gap, I used the model of multiple dimensions of identity (as shown in Appendix A) by Abes, Jones, and McEwen (2007). The model of multiple dimensions of identity depicts salient identities in a fluid and dynamic way. This model has two important aspects a) there is a core identity that remains constant and does not change with context and b) the identities that flow around core are most salient when they are closer to the core and less salient when they are farther from the core. In addition, identities can intersect with one another. This model is especially relevant for this study because it was refined using the perspectives of a diverse group of women, including women who self-identified as women of color. This model enables me to take on a multiple identities lens and investigate multiple identities of saliency from the student's perspectives.

Intersectionality (Collins, 2002; Crenshaw, 1991) work grew from the need to understand the experiences of women of color at the intersection of race and gender because aggregating experiences categorically "ignores intragroup differences" (Crenshaw, 1991, p. 1242). Intersectionality work calls for the use of intersectionality as "a critical analytic lens to interrogate racial, ethnic, class, physical ability, age, sexuality, and gender disparities." (Torres, Jones, & Renn, 2009, p. 588). As cited in Torres, Jones, and Renn (2009), using an intersectionality lens allows for the study of multiple identities and "larger social structures of power and inequality" (p. 588) for marginalized individuals. In addition to using a multiple identities lens to study the intersections of race, gender, and ethnicity, intersectionality enables me to connect the nuanced student experience to institutional structures of power and inequality. In engineering, intersectionality has not been used extensively, but more so currently. In engineering, intersectionality allows for an investigation of how a student's engineering experience cannot be understood solely by looking at one identity, but rather by looking at the intersection of identities (Riley & Pawley, 2011).

Discussion and Importance of Study

Research investigating the experience of Latina and Latino students in engineering is sparse and lacking, even more so when focusing on engineering identity development of these students. Because there are few Latinas/os often there is no statistical power to disaggregate the data and results are reported for aggregate groups losing the nuanced, individual student experience (Pawley, 2013). Although we know more about the aggregated group of underrepresented minority students in engineering, we also know that disaggregating by factors such as gender, race and ethnicity matters in that through such research we are able to investigate the nuanced experiences of students. Through previous research we know that students who are successful in engineering may have a strong self-concept and pre-college preparation, and access to formal and informal support networks including programs like minority engineering programs and student organizations. Being able to understand how members of student organization are influenced by such in their engineering identity development can give us an insight into how future Latina and Latino students can also be successful in engineering.

Statement of Purpose and Research Question

This study can aid in understanding the ways in which Latina and Latino student members of a professional organization construct their engineering identity. Understanding how these students develop their engineering identity can address retention of Latina and Latino students in engineering. The purpose of this study is to investigate the ways that Latinas and Latinos membership in the Society of Hispanic Professional Engineers influences their engineering identity development.

The following research question guides this study: In what ways and to what extent does membership in the Society of Hispanic Professional Engineers influence the engineering identity development of Latina and Latino students?

CHAPTER 3

Methodology

To answer the research question, I used a sequential and developmental mixed methods approach. The mixed methods approach consisted of two phases. In the first phase, I conducted interviews and observations to explore the ways that membership in SHPE influenced engineering identity development. Using the results from the first phase, I created and piloted a culturally situated engineering identity development survey in the second phase.

The two-phase developmental mixed methods approach allowed me to answer the research question for two reasons. First, interviews and observations allowed me to explore the ways Latina/o student members of SHPE are influenced via their involvement in the organization in their engineering identity development. Second, the survey served as a foundation to develop a culturally situated survey of engineering identity. The survey developed in this study addresses the ways SHPE influences the engineering identity development of Latina/o student members of SHPE. As explained more in depth in the following section, the use of mixed methods was key in developing an engineering identity survey for Latinas/os in SHPE.

Context of Study: Society of Hispanic Professional Engineers

The Society of Hispanic Professional Engineers (SHPE) is the largest engineering professional organization for Latinas/os in the United States. SHPE was founded in 1974 to create a network of support for students at the undergraduate level. SHPE is divided into seven regions across the country including Hawaii and Puerto Rico. Within those regions, student chapters can be established at a campus level. Aside from the university student chapters, there are also chapters for professionals.

SHPE's current mission is to change "lives by empowering the Hispanic community to realize its fullest potential and to impact the world through STEM awareness, access, support and development" (Society of Hispanic Professional Engineers, 2015). To achieve this mission, SHPE organizes professional and leadership events and conferences for students and professionals and STEM outreach events. At a national level, SHPE provides scholarship and other monetary resources for high school and college students to promote college going. At the chapter level, SHPE is run by its members, who organize events that meet the national mission. In turn, SHPE chapters also organize events to meet the national mission.

Use of Mixed Methods Approach

The definition of mixed methods research continues to be a topic of thoughtful argument (Tashakorri & Teddlie, 2010). Scholars generally agree that a mixed methods study incorporates at least one type of traditionally quantitative method and one type of traditionally qualitative method. Historically, mixed methods research was used to triangulate results and arrive at a convergent, more valid conclusion (Jick, 1983; Mathison, 1988). Triangulation and mixed methods research were justified in that one method's weakness would be naturally compensated by the other method's strength. In current mixed methods research thinking, researchers continue to consider each method's strengths and weaknesses (Johnson & Onwuegbuzie, 2004), but triangulation is not viewed as the only purpose for mixing methods.

The purpose for mixing methods is an important consideration because it can dictate how, why, and where mixing occurs. Greene, Caracelli, and Graham (1989) identified four purposes for mixing other than triangulation: complementarity, development, initiation, and expansion. With complementarity as the purpose of a study, researchers can focus on "enhancement" of results because one method complements another. With a development purpose, researchers can use the results of one method to develop a subsequent method in one study. With an initiation purpose, researchers can focus on "discovery of paradox and contradiction" in the findings of the study. Paradox and contradiction may be discovered through divergent findings that lead to more questions. Finally, with an expansion purpose, researchers investigate various phenomena by using multiple methods. Greene (2007) argues, "a study does *not* begin with design or method, but rather with a well-defined and well-justified purpose and a clearly delineated set of inquiry questions … methodology is ever the servant of purpose, never the master" (p. 97).

For this study, I used the following definition of mixed methods: "mixed methods social inquiry involves a plurality of philosophical paradigms, theoretical assumptions, methodological traditions, data gathering and analysis techniques, and personalized understandings and value commitments" (Greene, 2007, p. 13). The purpose of the mixed methods design in this study is development in that "the results of one method are used to inform the development of the other method, where development is broadly construed to include sampling and implementation, as well as actual instrument construction" (Greene, 2007, p. 102). In this developmental design, qualitative methods were used to develop a quantitative instrument in two sequential phases. The results from both phases, qualitative and quantitative, were respected and prioritized equally. Equally prioritizing both methods in one study allows the researcher to engage in a dialogic conversation that embraces the results from both methods equally. By prioritizing results from both methods the researcher is prompted to consider different ways of knowing.

The central phenomenon of interest in this study is engineering identity development. This phenomenon was explored in both phases of this study. Through the two-phase development mixed methods design, this study addressed a methodological gap in the literature because previous surveys of engineering identity have not been developed specifically for students of color, including Latina/o students, and thus may not be culturally situated for this population.

Figure 3.1 depicts representation of the research design, which includes attention to status (both phases will be prioritized equally), timing (sequential), and purpose (developmental). This design followed a mixed methods exploratory sequential design (Creswell, 2012). The first phase of the study was exploratory: the purpose was to explore a phenomenon through the use of qualitative methods. In the second phase of an exploratory sequential design, a quantitative instrument was developed to explain the phenomenon. Due to time limitations in my study, I did not fully address the explanatory aspect of this design. Instead, I created and piloted a survey. Using the data gathered from the distribution of the pilot survey, I tested for construct validity and reliability.

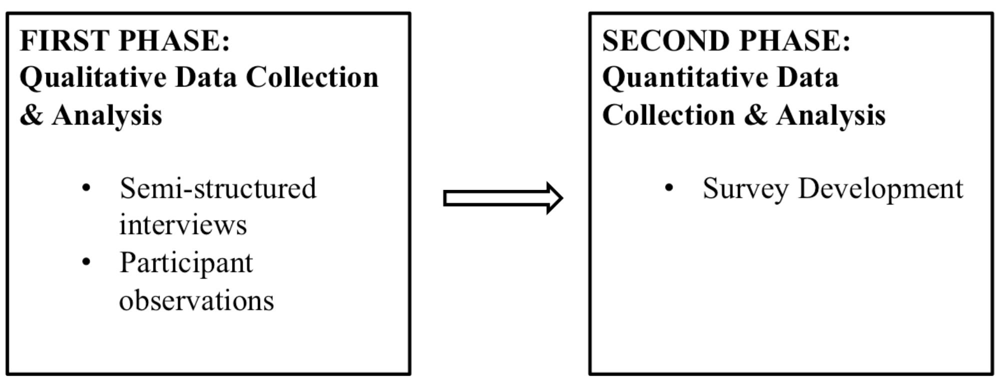

Figure 3.1: Mixed Methods Design

First Phase – Interviews and Observations

In the first phase, I conducted semi-structured interviews and observations of undergraduate student members of SHPE. I explored the ways a student identified as an engineer within the nested context of being a member of a SHPE chapter and a student in an engineering program. For the majority of these students their SHPE membership extended beyond their university campus. These students attended national conferences, won national awards, or undertook leadership roles at a national level.

Semi-Structured Interviews

I conducted semi-structured interviews with twenty undergraduates. The interview protocol is presented in Appendix B. The interview protocol was created and guided by three theoretical frameworks to elicit conversation about engineering identity development. Primarily, however, the interview protocol was informed by the Community Cultural Wealth (CCW) framework of Yosso (2005), who discusses the importance of understanding students of color as owners of capital rather than as capital deficient. These forms of capital are aspirational, linguistic, familial, social, navigational, and resistant. I created interview questions to have conversations with students about these six types of capital. Table C.1 in Appendix C shows how the interview questions mapped to the CCW forms of capital. The second framework that guided the interview protocol was the model of multiple dimensions of identity by Abes, Jones, and McEwen (2007). Using the lens of multiple dimensions of identity, I created questions that would stimulate conversations about various identities (e.g., ethnic, gender, generational) experienced by engineering student members of SHPE. The remainder of questions was guided by research literature on engineering identity (Meyers, Ohland, Pawley, Silliman, & Smith, 2012; Tonso, 2006). These questions were developed to elicit conversations about how students identify and are identified as engineers.

Participant sampling. I employed purposeful sampling to recruit students to participate in the semi-structured interviews. Purposeful sampling allowed me to achieve intensity and variation in the data by recruiting information-rich participants (Patton, 2002). The following student characteristics were used to recruit information-rich participants: major, ethnicity, gender, institution type, number of years as members of SHPE, and size of SHPE chapter.

With regard to major, I sampled participants who were undergraduate engineering students. As such, the majority of the student members in SHPE are undergraduates. The majority of students in SHPE major in engineering, or plan on majoring in engineering.

Keeping consistent with the research question, I selected students who self-identified as Latina and/or Latino. SHPE membership is not limited to Latinas/os, and in some cases students who do not self-identify as Latinas/os join SHPE. Because my study focuses on the ways that Latina/o students understand and construct their engineering identity, only students who self-identified as Latina and/or Latino were sampled.

Research about minority students in engineering reveals the existence of gender differences within racial and ethnic minority groups. In their review of the literature on women of color in STEM, Ong, Wright, Espinosa, and Orfield (2011) confirmed that women of color continue to experience a "double bind." The double bind refers to the "unique challenges minority women faced as they *simultaneously* experienced sexism and racism in their STEM careers" (p. 175). These challenges apply to students' academic careers while in college and university. The double bind for undergraduate women of color has been noted in the literature (Brown, 2008; Capobianco, 2006). Given the gender differences students might experience, I sampled students who identified as female and as male.

To obtain perspectives of SHPE members from various institutions, I sampled from predominantly white institutions and from minority serving institutions. As documented in the literature, students of color who attend predominantly white institutions, especially in STEM fields, can perceive a "chilly climate" – that is a climate that is unwelcoming of them (Seymour

& Hewitt, 1997). On the other hand, students of color who attend minority serving institutions may perceive a welcoming, not chilly, climate (Camacho & Lord, 2011). Because the student experience at these two types of institutions may differ, I sampled students from both types of institutions.

I sampled students who have been members of SHPE for at least one year. A one-year membership in SHPE is a significant time for a college student. In one year, students may have attended meetings, events, and the annual national conference. After one year, students could have also been involved as an officer or a member of a committee.

Data Collection and Participants. Using the sampling criteria outlined above, interview participants were recruited via an email message sent to all undergraduates who attended the SHPE national conference in Indianapolis, Indiana in October 2013. During short one-on-one meetings at the conference, I connected in person with over thirty of one hundred potential participants who had responded to the email invitation. During the individual meetings at the conference, I collected demographic information about the students to determine their fit for the study. As a group, the students with whom I met constituted enough variation in the data. That is, they were female and male students from different majors, institution type, and years of SHPE involvement.

In the spring of 2014, I sent potential participants a second email invitation to invite them for an interview. More than twenty potential participants responded, and I interviewed twenty-two of them. Two interviews could not be included in the study. One of the participants did not return the signed consent form despite several attempts to reach him. The other participant did not meet the criteria for the interview: he did not identify as Latina/o. The participant disclosed this information near the end of the interview. I interviewed the majority of participants virtually via video conferencing on Skype or Google Hangout. I interviewed three of the participants via phone call because video conferencing was not an option for them at the time of the interview. The interview length ranged from 27 minutes to 78 minutes. On average, each interview lasted around 50 minutes. All interviews were audio recorded and later transcribed verbatim.

Observations

To triangulate findings from the interviews, I was a participant observer at campus-level chapter events during the fall of 2014 and at the 2014 national SHPE conference in Detroit, Michigan. I have been involved in SHPE since 2003, and some of the people present during my participant observations knew me as a student of the university and also as a SHPE member. As a result, taking the role of a participant observer was an unobtrusive way of conducting observations.

I was a participant observer at a public, predominantly white institution in the Midwest, which I will refer to as Flatlands University. I attended SHPE chapter meetings and events, which were open to the public. At Flatlands University, the percentage of undergraduate Latina/o students in the spring of 2015 was 8.8% campus wide and 5.2% in the engineering college. Apart from SHPE, there are at least 17 other registered student organizations that specifically recruit Latina/o or Hispanic undergraduates. Students at this university can be members of more than one student organization. Flatlands University was a fit for this study for at least two reasons. First, it has a large, award-winning SHPE chapter that has had a history of success stories with its students locally and nationally. The history of this chapter and its members can provide an information-rich picture of active and successful SHPE membership. Second, Flatlands University is a public, research-oriented, predominantly white institution where students may experience a "chilly climate."

I was also a participant observer at the 2014 national SHPE conference. Undergraduate students as well as middle school, high school, and graduate students, professionals, company representatives, faculty members, and other sponsors gather at this large annual national conference attended by 2,000 to 3,000 people. The SHPE conference is attended by students around the nation from various types of colleges and universities, and various experiences with SHPE. At the conference, students attend workshops on leadership, professional, and career development. One of the main attractions at the conference is an extensive career fair where students can interact with hundreds of company representatives. During the conference, students can also participate in competitive projects such as technical paper competitions, academic olympiad, and extreme engineering, a technical design competition.

As a participant observer at Flatlands University and at the 2014 national SHPE conference, I sought events that interviewed students mentioned as important to their engineering identity development. Namely, at Flatlands University, I attended three general body meetings. At the national SHPE conference, I attended four workshops, presentations for an undergraduate design competition, one large gala dinner, and the career fair.

Interview and Observation Data Analysis

To analyze the interview data, I employed various forms and two cycles of coding primarily guided by Saldaña (2013). All rounds of coding were guided by the Community Cultural Wealth (CCW) framework. Microsoft Excel and HyperResearch were used in the analysis of interview and observation data.

For the first cycle of coding, I used emergent coding, as codes emerged from the data. Emergent coding was guided by the CCW framework. I used the forms of capitals as an overarching code and specific simultaneous codes when needed. For example, “aspirational capital” and “role modeling” codes were applied to text that represented role modeling as a form of aspirational capital. When appropriate, I also used the following forms of coding during the first cycle: simultaneous, in-vivo, process, and values. With simultaneous coding, the researcher can apply two codes to the same data “if data suggests multiple meanings that necessitate and justify more than one code” (p. 80). With in-vivo coding, the researcher is open to using actual language and terms used by the participant. In-vivo coding is especially important in this study because in-vivo coding helps to develop a survey that is culturally situated through the use of participants’ language and words. With process coding, the researcher codes instances where the participant “uses gerunds (‘-ing’ words) exclusively to connote actions in the data ... particularly [appropriate] for those that search for ongoing action/interaction/emotion taken in response to situations, or problems, often with the purpose of reaching a goal or handling a problem” (p.96). Process coding was chosen because of the developmental nature of identity. Identity development can be an action/interaction/emotion in response to situations or problems. With values coding, the researcher codes data that reflect a participant’s values, attitudes, and beliefs. This type of coding was important in this study because it helped to explore “cultural values, identity, intrapersonal and interpersonal participant experiences” (p. 111) many of which can be ongoing processes as students develop as engineers.

The objective of the second cycle of coding was to construct themes or categories from patterns that emerged in the first cycle of coding. One of my primary goals using thematic analysis was to perform construct identification (Teddlie & Tashakkori, 2009), in order to arrive at constructs that were grounded in the interview and observation data. During the second cycle of coding, I reviewed all of the interview data again and the observation data. Throughout this process, I wrote analytic memos to reflect how the codes were lumped into categories or themes (Saldaña, 2013). These analytic memos were written for each code that emerged during the first cycle of coding and were recorded onto a Microsoft Excel spreadsheet. After this process, I created a second HyperResearch file to reorganize the codes into the newly developed categories and themes. Table 3.1 shows the categories and themes developed after the second cycle of coding. The themes in Table 3.1 are presented in Chapter 4. These themes were developing professional and leadership skills (Theme 1), having an impact in the community (Theme 2), being and finding engineering role models (Theme 3), and nurturing an engineering *familia* (Theme 4).

Table 3.1
Codes and themes after second cycle of coding

Code Name	Theme	Code Description	Example
Professional	Theme 1	Developing professional skills	"We [SHPE] provide a channel to, for professional development, how to dress, how to umm write your resume, how to talk to professionals, or how to approach professionals, interviewing techniques." –Jacob
Leadership	Theme 1	Developing leadership skills	"SHPE is one of those organizations for me that have helped me to grow as an ... not only as an engineer, but as a leader. It's helped me develop leadership skills." –Edgar
SHPE national conference	Themes 1 & 3	What students gained at the SHPE national conference	"The national [conference] alone, there is a lot of networking so there is a lot of face to face time with a lot of recruiters and that career fair is one of the biggest, no, the biggest career fair that I've ever seen, whether in person or on video, and that's one really big opportunity." –Mike II

Table 3.1 (cont.)

Getting a job	Theme 1 & 4	Being able to get a job through contacts or events in SHPE	"Professionally, SHPE really at least the members in SHPE really helped me out since freshman year go out and at least start networking with these different companies and be able to expose myself up to these recruiters in a professional manner ... So because of SHPE I've been able to have a good problem: where I was actually struggling to decide where I wanted to go work because I had so many offers and it was mostly led because of SHPE." –Bob
SHPE *Familia* / Home away from home	Theme 4	Having a family of engineers / support from peers in SHPE	"They [SHPE peers] were like my brothers and sisters at the time so ... we took care of each other.... And then of course there is the *familia* aspect so you have, as soon as you join you have a huge network of people who want you to succeed and will help you succeed." –Cesar
SHPE Professional Chapter	Theme 3	Having support from SHPE professional chapters	"They help you connect a lot with professional chapters or so that you can talk with the professional chapters and do mock interviews with them all the time and that helps you gain more confidence." –Joaquin
NILA	Theme 3	Attending National Institute for Leadership Advancement (NILA)	"I went to NILA and really I think that was probably one of the biggest conferences that I took away from as far as developing those leadership skills and time management skills." –Hector
Noche de Ciencias	Theme 2	Being part of science outreach called *Noche de Ciencias*	"Also I really like the fact that, that giving back to the community by doing things like *noche de ciencias* (science night) was really ... something really great that I can involve myself in and also connect with the kids so they can get inspired as much as I got inspired to be an engineer." –Robby
"Not all just about you"	Theme 3	Helping other engineering and SHPE students	"I think that it's [SHPE] made me more humble, I think that there is a lot of engineering students who are very mmm arrogant. Mmm because you know with engineering, a challenging major, and then if they made it they're like 'Oh, I'm best the student.' But I think it's made me more humble in the sense that it's not all just about you and that you can help other engineering students also prosper. So I initially started off my SHPE career very focused on just me, but toward the end of being a SHPE member I definitely became more humble and wanted to help other students also prosper." –Karina

Table 3.1 (cont.)

Help community / Giving back	Theme 2	Doing community outreach and giving back to the community	“SHPE does a lot of community outreach and I think because of them, you know, it's always in the back of mind, you always have to give back.” –Linda
"People that are more like me"	Theme 4	Having people who are more like the students in their engineering support system	“Well being a part of SHPE has definitely been encouraging because at my university we are a majority white male university and there aren't very many females in my class and there aren't very many Hispanic people in my class, and so having that group of people that are more like me I can sort of relate more to them, it's been really nice.” –Emily
SHPE support	Theme 4	Expressed forms of SHPE member (formal and informal) support during engineering journey	“You know, just the conversations I've had talking with people and telling them how I felt and how sometimes I felt like I shouldn't be going to college and how I probably was gonna fail out and drop out and they were always like ‘No, everybody goes through this, there is people in SHPE that have been here for like 9 years, but it's okay you know, it doesn't matter how fast you finish.’” –Anthony
SHPE advisor	Theme 4	Had support from SHPE advisor during engineering journey	“I would have to say my SHPE advisor at my university. She has been one of the biggest support I’ve had, she has been like a second mom to me here.” –Joaquin
Minority Engineering Program (MEP) Advisor	Theme 4	Had support from MEP advisor during engineering journey	“When I met with [MEP adviser], yeah he didn't do anything, but that encouragement really helped like I didn't ever dream of going to [Midwest University] but that encouragement that he said like ‘yeah you can come if you get good grades in your first two years at [Other University],’ that was like, that was a big encouragement to keep going and try to achieve more and more.” –Mike

Trustworthiness

Trustworthiness and rigor of this research study were addressed using standard practices (Lincoln & Guba, 1985): paper trail, member checks, peer debriefs, and joint data analysis.

I kept a paper trail throughout the research process that included interview documents, consent forms, a researcher journal, any type of communication with participants, observation notes, and analyses documents.

To address the quality of the data, I took notes during each interview, which were incorporated into the data analysis. I reflected on the quality of the data after each interview by answering post-interview reflection questions (Patton, 2002) such as: “How did the interviewee react to the questions?” and “How was the rapport?” After the first cycle of coding, I conducted member checks via the phone with twelve participants. During this phone call, I asked the participants for their feedback and comments on the themes constructed after the first cycle of coding. The themes presented to the participants during the member checks are documented in Appendix D. All of the students with whom I conducted member checks agreed with the themes.

After the first cycle of coding, I consulted with two peers for feedback on the findings. These consultations informed the second cycle of coding. Specifically, we discussed how the categories and themes mapped to the forms of capitals in the Community Cultural Wealth framework.

Prior to this project, I had not used the Community Cultural Wealth (CCW) framework to guide data analysis. To address my ability to code the interviews with accordance to the framework, I collaborated with a graduate student who had previously worked with the framework to assist me in joint analysis. We coded three interviews individually and met virtually, via Skype, twice to review the interviews. In our first meeting, we discussed one interview and negotiated on codes. In our second meeting, we discussed the remaining two interviews and completed negotiating codes. Each interview took at least an hour to discuss and analyze together. Through extensive dialogue (Saldaña, 2013), we concluded that we agreed about the vast majority of codes.

Second Phase – Survey Development

Keeping consistent with the development purpose of this mixed methods study, the second phase was designed to develop a valid and reliable engineering identity survey for Latina/o students in SHPE.

Survey Construction

As reported in Crede and Borrego (2013), using interview and observation data prior to creating a survey has implications in the "importance of understanding the social, cultural, and personal factors about a population prior to conducting quantitative research" (p. 76). Literature on the process of translating themes or categories into survey constructs is sparse. Crede and Borrego suggest looking at patterns across interview and observation (among other ethnographic data) as a starting point. A researcher would then translate these patterns and larger themes into survey constructs and finally survey items.

The constructs in this survey were derived from the themes found in the second cycle of coding during the first phase of this study. These constructs were commitment to community, developing as a professional, developing as a leader, being an engineering role model, and having a *familia* of engineers. Though these constructs were guided by the CCW framework, I purposefully decided not to create constructs directly derived from the CCW framework (e.g., having aspirational capital as a construct) because the different types of capital in the CCW framework overlap and are not necessarily independent of one another (Pérez, 2012; Yosso, 2005).

I used the codes developed in the first cycle of coding to create survey items for each survey construct. With the goal of creating a culturally situated survey of engineering identity development for Latina and Latino students, I used much of the conversation and language gathered through the interviews and observations. Additionally, though the interview protocol did not directly address motivation behind studying engineering, one motivation that students discussed in interviews was intrinsic motivation to study engineering. As a result, I used already-developed survey items for the construct intrinsic motivation from Sheppard et al. (2010). The survey items developed in Sheppard et al. (2010) were not developed specifically for Latina/o students. However, I incorporated them into the survey because some of the students mentioned this motivation to study engineering. More detail on the construction of survey items provided in Chapter 5.

Survey Development

After the survey items were constructed, I followed survey standards (Groves, Fowler, Couper, Lepkowski, Singer, & Tourangeau, 2009) that all survey items should meet in order to minimize measurement error. The standards are classified in three categories: content, cognitive, and usability.

To address content standards, whether the survey items are asking what they are intended to ask, I sought feedback on the survey items from content area experts. Experts included two scholars in the field of higher education and engineering education and potential survey takers. These experts were familiar with the content of the survey. Through this review process, I ensured that the survey items mapped to the constructs and that they were aligned with the overall research questions.

To address usability and cognitive standards, I consulted with a survey expert to ensure the survey items were appropriate in wording, structure, and formatting. After the survey expert consultation, I changed the survey in the following ways. First, I changed leading questions to balanced questions. Leading questions, such as some yes or no questions, are unbalanced and could lead to acquiescence bias (Saris, Revilla, Krosnick, & Shaeffer, 2010). Instead of asking the survey respondents, “Do you consider yourself an engineer?” with yes or no answer options, I asked them, “Which of these statements best describes you?” and provided item-specific response options. Second, instead of presenting a matrix of questions in one page, I opted for one question per page. When each page has only one question, survey respondents concentrate on each question at a time. Conversely, a matrix or grid of questions can overwhelm the survey respondent and cause survey breakoffs, item missing data, and respondent dissatisfaction (Tourangeau, Couper, & Conrad, 2013). Another reason for presenting one survey question at a time is that questions that are positioned higher up on the screen are rated more favorably than questions that are positioned at a lower location on the screen (Tourangeau, Couper, & Conrad). Third, I reworded and restructured agree/disagree questions. Saris, Revilla, Krosnick, and Schaeffer showed that agree/disagree questions had lower quality than item-specific response questions. Agree/disagree scales have also been shown to have more acquiescence bias from survey takers because survey takers more often agree with the statement regardless of the question (Bishop, Oldendick, & Tuchfarber, 1982; Gendall & Hoek, 1990; Kunda, Fong, Sanitioso, & Reber, 1993). Finally, I used a unipolar scale (with four to five items) for maximum validity and reliability (Dillman, Smyth, & Melani Christian, 2010).

To address cognitive and content standards, I conducted two separate cognitive interviews with content area experts. These interviews helped to address the understanding of each survey item. The content area experts were undergraduate engineering students who were members of SHPE at the time of the cognitive interview. During the interview, I asked the content area experts to take the survey as if they had received it via email. After they took the survey, I asked the content area experts to do retrospective think-alouds (Groves et al., 2009) for every item. In a retrospective think-aloud, the respondent is asked a series of questions about how they answered the survey items. These questions probe about the cognitive process of answering a survey item. Through feedback from the retrospective think-aloud, a researcher can also optimize wording and formatting of the survey items. The content area experts provided wording and format changes to the survey. The annotated changes to the draft survey (Appendix E) are documented in Appendix F. After the changes were made, I pilot tested the web survey with three more content area experts; they had minimal formatting changes. The final web survey is shown in Appendix G.

CHAPTER 4

Qualitative Phase

In this chapter, I present the results from the first phase of the two-phase mixed methods study. The methods used in the first phase consisted of twenty semi-structured interviews and participant observations.

Overview of Interview Participants

Table 4.1 depicts a summary of the interview participant data. The interview participants were eighteen years or older, engineering undergraduates, and members of SHPE for at least one year. All of the participants self-identified as Latina/o, and six of the participant identified as female. When asked about their family's ethnic background, the participants traced their ethnic background to these Latin American countries: Mexico, Puerto Rico, Dominican Republic, Cuba, El Salvador, and Chile. Of the 20 participants, 8 were transfer students, 12 were first-generation college students, and 17 attended public colleges or universities. For the remainder of the chapter, I refer to the interview participants as "students."

Table 4.1
Interview Participants' Demographics

Pseudonym	Gender	Year in University	Engineering Major	University Location	HSI Status	Years as SHPE member
Karina	Female	4^{th}	Mechanical	New York	Non-HSI	5
Emily	Female	2^{nd}	Electrical	Missouri	Non-HSI	2
Cosmo	Male	4^{th}	Mechanical	Florida	HSI	1.5
Cesar	Male	4^{th}	Computer Science	Illinois	Non-HSI	4
Edgar*	Male	5^{th}	Architectural	Kansas	Non-HSI	5
Robby	Male	6^{th}	Electrical	California	Non-HSI	6

Table 4.1 (cont.)

Manolo	Male	6th	Mechanical	California	Non-HSI	5
Linda	Female	4th	Materials Science	Illinois	Non-HSI	4
Bob	Male	5th	Civil	Illinois	Non-HSI	5
Joaquin*	Male	4th	Mechanical	Ohio	Non-HSI	4
Ivan	Male	3rd	Chemical	Puerto Rico	HSI	2
Isabel*	Female	1st	Civil	New Jersey	Non-HSI	1.5
Jacob	Male	6th	Mechanical	California	HSI	6
Fernanda*	Female	4th	Computer	New York	Non-HSI	2
Mike	Male	3rd	Electrical	Illinois	Non-HSI	3
Hector	Male	4th	Mechanical	Colorado	Non-HSI	4
Anthony	Male	4th	Mechanical	Colorado	HSI	5
Luis	Male	3rd	Mechanical	California	Non-HSI	2
Carol	Female	3rd	Mechanical	Pennsylvania	Non-HSI	4
Mike II	Male	2nd	Electrical	Texas	HSI	2

Note. Pseudonyms with an * were chosen by researcher

Pre-college engineering identity

To understand how the students developed their engineering identity, I talked with them about their journeys going into college. These conversations elicited information about a) how students begin to think of themselves as engineers, and b) how a pre-college engineering identity may play a role in their ongoing engineering identity development during college. I asked the students two primary questions about their journeys to college. First, “what was your journey to college like?” And second, “was your journey to college different than your journey towards engineering? How?” These questions were based on pre-college literature, with a specific focus on access and awareness of engineering.

The majority of the students were not involved in STEM programs or courses during high school. Four students took engineering-related courses in high school; one student took a computers course in middle school. Eight of the students were involved in pre-college STEM academic programs; the majority of these eight students participated in programs that had a specific focus in engineering. For those who participated in academic STEM programs or took engineering courses during high school, they reported that these programs and courses sparked or reinforced their interest in engineering.

A minority of the students learned about engineering through their high school teachers or counselors. Six of the students mentioned their high school teachers as sources of knowledge or encouragement to go into engineering. Only one participant mentioned their high school counselor as a source for learning about engineering. Isabel described the type of exchange high school teachers had with students to encourage them to go into engineering.

> I had a math teacher in my senior [year of high school], he was my calculus teacher and he asked us one day, like everybody in the class, like what we wanted to do in college since it was close to the end of school like when you're getting, not the end of school but mid year, senior year like when you're applying to the colleges, he asked us, everybody, like what we wanted to do, and when it came to me, I told him I wanted to be architect, and he told me “Why do you want to be an architect?” And I was like “Oh, I want to study architecture, I want to draw buildings, I want to design them” And he told me, he was like “Well, you're good at math and you like, you like science, right?” And I'm like

> "Yeah" and he was like "You know, you're a smart person you can do something like architectural engineering." –Isabel

One reason students mentioned for pursuing engineering as major was that they were intrinsically motivated to study engineering. Five students expressed an intrinsic interest for learning about engineering that led them to want to major in engineering. They vocalized this intrinsic interest as a "thirst for knowledge" and a "fascination with engineering." One of the students, Edgar, realized this interest as an older adult; he attended a few years of community college and technical school before going into engineering.

> Growing up I've always had a fascination with engineering and I knew that's what I wanted ... I knew that's what I wanted to do growing up. –Edgar

Another reason students gave for pursuing engineering was being good and liking math and science. Eight of the participants mentioned that they decided to pursue engineering because they were good at math and science and they liked the subjects. Additionally, two students chose their majors (computer science and computer engineering) because they loved computers. The quote below from Isabel shows her reasoning for pursuing engineering.

> I always, once I told my parents that I wanted to do *ingeniería* they're like Really, isn't that for men?" And I'm like "Well I kind of want to, I'm good at math, I like to draw, and I like science so I think I want to do something that requires more than drawing" You know I didn't want to go into, I wanted to do something where I could use math, I could use subjects that I liked so that's why I went into engineering and yeah, everyone used to tell me in my family "But why? But why?" And I'm just like "I want to!" I want to do something behind like, I just want to do something that I can use math, like I said, not just… How can I say this? Like I want to do more, you know? Engineers,

> we're more of like the brains of things and I think that's, that's what I would see myself as, so I decided to do engineering. –Isabel

Students were also motivated to go to college and to major in engineering because of their families. Parents, siblings, uncles, aunts, and grandparents were some of the key people who motivated students to continue to achieve in their education beyond high school. The majority of parents did not explicitly tell students to study engineering; however, they continuously reminded students that they should take advantage of the opportunity to pursue college, which the parents did not have.

> My father was always telling me how he wants me to go to college to get an education because he never really had that opportunity when he came from Cuba and my grandparents were constantly saying “oh we want to see you graduate.” –Cosmo

Aside from explicitly telling the students to achieve, parents, uncles, and aunts also motivated the students to continue their education by showing them the kind of work they had to do.

> I worked in the fields with my uncle, and it was so hard, it was hard waking up early in the morning and getting out late in the afternoon, and I told myself, you know “This is not what I want for my life.” I want to be, I don't want to say I want to be better than my parents, but I want to have a better job than what my parents had and so I decided you know, I don't want this, I want to go college, I want to be, I want to wake up at seven, go to work at 8, come out of work at 4 or 5, and come out clean. That's what I thought, you know. I wanna come out clean, not dirty and stuff so. Basically it was seeing my parents work hard and seeing what they have done so, and my uncles pushing me to go to college and talking about college to me. –Luis

With regard to how students learned about engineering, half of the students did not know any engineers growing up formally or informally. Two of the students had parents who were engineers. For one of the students both parents were engineers, and for the other student only the father was an engineer. Eight students knew engineers through informal and formal job shadowing, high school programs, family connections, and teachers. Three of the participants shadowed an engineer prior to attending college. Two of the opportunities to job shadow were arranged by family members (mother and aunt) and one of them was set up by high school teacher.

Whether students considered themselves engineers

The majority of students considered themselves engineers or engineers in training. Twelve of the students answered that they considered themselves engineers when asked the question: “would you consider yourself an engineer?” One of these twelve students considered himself a scientist as well as an engineer. Six of the students considered themselves aspiring engineers or engineers in training. Two of the students considered themselves only engineering students and not engineers. Manolo explained why he considers himself an engineer in training:

> I would consider myself capable of becoming an engineer. At this point, would I call myself a full-fledged engineer? No. Umm, and the reason for that is I think I’ve proven to myself that I can learn what I need to learn to accomplish something, but I, although I do feel like I like taking leadership roles, umm I do know when there is something I don't know, and I don't feel that as an engineer I could go somewhere right now and say “I am the expert here and I know what we need to do 100%” I have taken, though, my state certification testing, the engineering in-training test or licensure, and I passed that so I received my [engineer in training] certificate now so I guess in California I am certified

> as an engineer in training and that's how I would refer to myself, if someone asked me if I was an engineer. –Manolo

Other students echoed Manolo's reasoning for considering himself an engineer in training instead of considering himself solely an engineer. They also considered themselves engineers in training because they were still in the process of obtaining their engineering degrees and they did not yet have their "official titles."

What it means to be an engineer

As these students develop and identify as engineers, their conceptualization of what it means to be an engineer changes continually. However, at the time of the interview, the students shared their current conceptualizations of how and why they viewed themselves as engineers.

When I asked the students to describe what it meant for them to be engineers or engineers in training, overwhelmingly the students thought of engineers, and themselves, as problem solvers. Being a problem solver entailed being able to identify a problem and design a working solution. Some of the problems that students talked about were generic analytical problems, perhaps mirroring what they were learning in the classroom. However, some students discussed solving larger societal problems like "making the world a better place." For example, Luis said he considered himself an engineer because he was always trying to solve problems and "make stuff easier" for him. He gave the following example of problem solving a real-life situation that would help him and his family, who were farm workers,

> I would have to pick up *apio* [celery] with my hands so, I thought to myself "This is pretty hard, man, how can I make it easier for myself?" So and then … then with the help of my grandpa, I built a little car, like a little car that I was able to, with big tires, it was huge and I took it to the field once and everybody laughed at me, "Oh, what are you

> doing with this here?" And basically, from picking up one stack, I was able to do five stacks instead of one, if I just pushed it at the end of the tractor, and it made my life easier in the fields so yeah so basically that's how I consider myself an engineer. –Luis

Other students discussed how being a problem solver also meant being creative in finding solutions and having "an imagination to see, to think out of the box." In the students' definitions, a problem solver is not only an engineer who is able to solve problems, but also one who has the skills to solve problems with a purpose and an open mind.

Later in the interview, when we talked about how SHPE has helped the students develop as engineers, they uncovered other aspects of their engineering (and perhaps personal) identities that reached beyond being a problem solver. These aspects of their engineering identities are represented in the following four themes.

Themes and Analysis

I found four themes that address the role that SHPE played in the interview participants' engineering journeys. These themes were analyzed using Yosso's (2005) Community Cultural Wealth framework, which was described in Chapter 3. Connections to the framework are presented along with each theme.

Theme 1: Developing professional and leadership skills

Through their involvement in SHPE, students developed professional and leadership skills that contributed to their development as engineers. When asked, "what role has SHPE played in your journey as an engineer or engineering student?" the majority of the students answered that SHPE helped them develop as professionals and leaders in the field. As explained in Edgar's representative quotation below, students highlighted SHPE's professional and leadership development workshops. The professional and leadership development workshops were organized by SHPE chapters at the campus-level and by the SHPE national office at the national SHPE conference. They served as primary avenues for the students' professional and leadership development.

> SHPE has played an important role for me. It's helped me develop as a professional and as a leader ... I've been able to attend several of the SHPE national conferences and through those conferences, ... I've gotten to network and connect with employers, I've gotten to connect with representatives from graduate schools and I've gotten to make connections with students from other [chapters] and it's helped me develop professionally...So for me SHPE has been a big part of my journey as an engineer and an engineering student. –Edgar

At the four-day annual conference, students can network with potential employers and SHPE alumni. As a participant observer, I attended three workshops at the national conference. Two of the workshops were marketed as leadership development workshops, and one was marketed as a professional development workshop. These workshops were hosted by General Electric (GE), Verizon Communications, and Intel. Dressed in professional attire, the students sat in lecture-style rooms as the presenters talked about their backgrounds, their professional journeys, and their companies. For example, the GE presenter discussed "Leadership & Growth Values at GE," and the Verizon Communications presenter discussed "Setting SMART Goals & Objectives." The presenters at all of these workshops identified themselves as Latinas/os and engineers.

Almost all the students mentioned the career fair during the national conference as an avenue for professional development. The career fair is one of the largest events during the national SHPE conference. In 2014, the ribbon cutting ceremony, to officially open the career fair, was led by a local Detroit band with saxophones and drums. The band and the national

SHPE board walked and danced towards the entrance to the career fair to initiate it. Students, dressed in professional attire and with resumes and portfolios on hand, awaited impatiently near the entrance. The career fair hosted hundreds of companies to recruit students. As Emily pointed out, the career fair can be an invaluable opportunity and in some cases irreplaceable for students' professional career advancement.

> I actually got an internship through the national conference, mmm, the employer who recruited me doesn't come to any career fairs at my school or anything so I would have never been able to connect with them if I hadn't gone to the conference, and I did and I ended up getting a job with them. –Emily

Finally, in addition to the workshops at the national SHPE conference, students mentioned that the local workshops organized by SHPE chapters contributed their development of professional and leadership skills. Below, Bob recounted the role his local chapter had in his professional development.

> Professionally, SHPE really, at least the members in SHPE, really helped me out since freshman year [to] go out and at least start networking with these different companies and be able to expose myself up to these recruiters in a professional manner ... So because of SHPE I've been able to have a good problem: where I was actually struggling to decide where I wanted to go work because I had so many offers and it was mostly led because of SHPE. –Bob

Some of the professional and leadership skills mentioned by the students were communication, networking, and interviewing. Jacob's quotation below provides more specific instances of what students meant by professional and leadership development.

> We [SHPE] provide a channel to, for professional development, how to dress, how to umm write your resume, how to talk to professionals, or how to approach professionals, interviewing techniques. –Jacob

At the campus level, students had the opportunity to take on leadership roles by serving on their chapter's executive board. As shown in Table 5.3, the majority of students interviewed (56%) served on the executive board at some point during their membership. In the quotation below, Bob discussed that by being president of a SHPE chapter he developed his leadership skills.

> It [being president of a SHPE chapter] really developed my skills of being to delegate work and being able to effectively communicate with people because I didn't do all that on my own, I had help from my board, but I feel that I wouldn't have that incentive to develop all those skills if I wasn't placed in that situation. –Bob

As evident from these representative quotes and student experiences, professional and leadership development was an important aspect of the students' engineering journeys and SHPE's role in those journeys.

Theme 1 draws on the following four types of capital: social, navigational, resistant, and linguistic.

Social Capital. Students drew on their social capital through the use of SHPE's resources for professional and leadership development. One resource that students had access to via SHPE was a "huge network of people." Via this network, the students acquired professional and leadership skills that helped them develop as engineers. As evidenced in Edgar's quotation below, through their connections with employers, students, and engineers, students employed their social capital to develop as leaders and professionals.

I've gotten to network and connect with employers, I've gotten to connect with representatives from graduate schools and I've gotten to make connections with students from other [chapters] and it's helped me develop professionally ... So for me SHPE has been a big part of my journey as an engineer and an engineering student. –Edgar

Similarly, in Manolo's quotation below, shows how students develop as professionals through their access to network of people.

I think an example about being professional is one of my role models, the one who was president [of SHPE] when I was the academic chair. He would always come to meetings dressed professionally, wasn't dressed flashy or anything like that, but with a collar shirt, with slacks, with a tie, he always motivated us to be prepared so we would have our meetings and we learned to be professional. –Manolo

Besides having access to the network of people in SHPE, students also had access to resources like the national and regional workshops to develop their professional and leadership skills.

If you're looking for a job, they [SHPE] have many workshops or so on how to do the right interview, how to talk to an employer, how to do this and how to do that. –Joaquin

Both the access to network of people in SHPE and the resources students had within SHPE were critical for the students' development of professional and leadership skills.

Navigational capital. The students used and strengthened their navigational capital through the professional and leadership skills they nurtured within SHPE. The skills learned in their professional and leadership development helped the students navigate their engineering profession and field.

By developing their professional and leadership skills, the students felt equipped to navigate the engineering field and profession. For example, students talked about learning how to dress and prepare for an interview, how to talk to company recruiters, and how to network. In the quotation below, Edgar elaborated about how these skills he acquired through SHPE helped him to navigate the engineering profession.

> When I first joined the organization, I had no idea how to speak with people from industry or people from academia and one of the things that we do in our campus is that we bring speakers from different fields of industry to talk about their line of work, and these speakers provided opportunities for me to that ... and I've been able to develop networking communication skills. –Edgar

Similarly, Cosmo described how he learned about internships through SHPE,

> I mean because of SHPE I realized that internships were kind of a thing ... mmm I've ... a lot of them they would constantly bring in people [speakers] to talk about how the best way to act in an interview, how to present yourself, and I picked up a lot of those tips and they really helped me. –Cosmo

Through the development of professional and leadership skills, students enhanced and used their navigational capital. Developing professional and leadership skills helped the students navigate their engineering field and profession.

Resistant Capital. Students exhibited resistant capital in prioritizing SHPE’s resources versus other resources in their professional and leadership development. Generally, students made the decision to use SHPE’s resources (e.g., workshops) for their professional and leadership development even when they had other resources available to them. During member checks, I asked the students (n = 12) about this pattern and they all agreed that they primarily used SHPE’s resources for professional and leadership development. They added that SHPE and the SHPE *familia* provided a level of comfort that made the choice of attending SHPE’s workshop versus non-SHPE workshops easier. Robby’s quotation below exemplifies the comfort and familiarity that some students may consider when they choose SHPE workshops or resources versus non-SHPE workshops or resources.

> The members feel more comfortable going to SHPE and using the resources that SHPE has because they’re more familiar and they’re connected with the students and they work together. That’s probably why they feel more comfortable using those resources than the university’s. –Robby

In other words, students exhibited resistant capital in their decision to prioritize SHPE’s resources over other resources for professional and leadership development.

Linguistic Capital. Linguistic capital played a role in the way that students, who identified as bilingual, reframed their bilingualism as an asset for their engineering careers. Bob shared his views on reframing his bilingualism for the engineering profession,

> So I'm not saying that Spanish is greater or less beneficial than English, but being able to have both you can be more of a benefit to a company. And that's what I've seen, especially companies who do have operations in different countries. When they realize that I can speak Spanish proficiently, to a point that it's not just conversational, but you can actually get work done through that language, it's a whole different set of doors that are open to me. It went from being a disadvantage or something that made me different to even though it still makes me different but it's more of an advantage nowadays. So I think it plays a crucial role especially in the Latino community that for someone to grow up at least having your identity, you as a United States American, but at the same time being

> able to find your roots and identify yourself with the language of origin that your family eventually comes from. –Bob

Theme 2: Having an impact in the community

Through their involvement in SHPE, the students were able to have an impact in the community. More important, the students viewed their ability to have an impact in the community as congruent with their engineering identity development. Students felt they had an impact in the community through outreach to middle schools and high schools. One of the outreach programs that was mentioned by most students was *Noche de Ciencias* (Science Night). *Noche de Ciencias* is an outreach science and engineering program for middle and high school students and their parents.

> So we have a whole day for elementary [school] kids, a whole day for middle school kids, and a whole day for high school kids and to see the gears turning and to see those smiles, the frustration, and the face of accomplishment when they do these and participate in these events is really gratifying because you know, you're starting the fire, or you're getting the gears turning and possibly influencing future engineers –Mike II

As Mike II pointed out, being able to inspire kids to go to college and pursue a STEM career was a way to have an impact in the community. In the quotation below, Manolo discussed mentoring programs that he felt had an influence on the mentees to pursue engineering.

> We [SHPE] did some mentoring programs, and I remember just being able to meet those elementary school kids or high school kids and motivate them to like "Oh, this is really cool, I want to be an engineer now or I want to learn how to do this or that" –Manolo

As Roby explained, for some of these students, inspiring others to pursue engineering was part of giving back and reciprocating because others had inspired them to pursue engineering.

> Also I really like the fact that, that giving back to the community by doing things like *noche de ciencias* (science night) was really ... something really great that I can involve myself in and also connect with the kids so they can get inspired as much as I got inspired to be an engineer –Robby

Aside from having an impact in the community through outreach, the students also expressed commitment to their community. The students' commitment was exhibited through their service. Students engaged in community service through their involvement in SHPE, as shown in Linda's representative quote.

> SHPE does a lot of community outreach and I think because of them, you know, it's always in the back of mind; you always have to give back. –Linda

Through their involvement with community outreach activities and community service, these students maintained their ties to their communities or the community at their university or college because the majority attended universities or colleges away from their home communities. Their commitment to the community was an integral to their engineering identity development.

This theme draws on the following forms of capital: aspirational, resistant, and familial.

Aspirational capital. Through their community outreach and community service, students used their aspirational capital to inspire others to pursue engineering. The students participated in programs like *noche de ciencias* because they could inspire middle school and high school students to pursue engineering by nurturing a "culture of possibility" (Yosso, 2005, p.78). In this case, the interviewed students nurtured a culture of possibility that would enable younger students to aspire to go to college and to pursue an engineering career. After discussing *noche de ciencias*, Mike II discussed the importance of being involved in outreach programs to kids for Latinas/os,

> So that's really gratifying when you see those kids walk out of there all happy that they were doing math, science, and engineering and that it worked out for them. Which you know it's not a really common theme among young kids. –Mike II

Through their commitment to and involvement with their community, students used their own aspirational capital to inspire middle and high school students to pursue engineering.

Resistant capital. Resistant capital manifested in the way that students justified their involvement in the community, especially through STEM outreach students. Many of the students expressed being motivated by the larger goal of SHPE to "bridge the gap between Latinos and college," as Linda put it. Through this motivation, students acted as agents of change and resisted the stereotypes about the academic achievement of Latinas/os. Linda's representative quotation below shows the use of resistant capital.

> The whole outreach, trying to outreach to Latinos, not only that are college undergraduates, but also high schoolers or grade schoolers, just outreaching to them to show them that they have the potential to attend college. When I said, the whole what SHPE stands for, I kind of meant bridging the gap between Latinos and college and I feel like that's a large part of what SHPE does and what SHPE needs to do. A lot of us, when I was [at the university], felt that way. –Linda

Although bridging the gap between Latinos and college is part of a SHPE national goal, many of the students talked about this goal implicitly. For example, Carol, a president of a SHPE chapter, discussed her chapter's outreach to the "Hispanic community" near her university to provide information about college.

> So that's kind of been one of our targets like with SHPE getting into the Hispanic community and like making them aware that there is financial aid and scholarships and things like that. –Carol

Familial capital. Students employed their familial capital by being invested in the well being of the community. Specifically, students expressed the need to "give back" to other Latina/o students through community outreach. The need to give back was rooted in a commitment to the community well being. In the case of the interviewed students, community well being primarily referred to the well being of middle and high schoolers in the students' home community or the community surrounding the university campus. As an example, Bob, as an outreach committee member, decided to establish a junior chapter at a high school surrounding the university community. The university community was far away from most of the SHPE members' home community.

> SHPE has always been involved with the [large city in the state] area high schools umm but when I was able to kinda get the gears rolling with one of our SHPE junior chapters in [city near university], that was really rewarding…it was the first couple of steps towards making an impact here in this community because we have three high schools here that we had not tapped into at all. And to be able to kind of integrate them with the programs that we have and pay it forward because at the end of the day, the university's home city is [city near university]. –Bob

Students were compelled to ensure the wellbeing of their home community and the community surrounding their universities by being engaged in outreach with kids.

Theme 3: Being and finding engineering role models

SHPE played an important role in the students' engineering identity development by providing a way for students to serve as engineering role models to others and to find engineering role models for themselves. As part of their engineering journey, students took an active role in being engineering role models for prospective and current engineering students. They talked about not just setting an example for other students, but also being active participants in other students' successes. Bob, a senior in civil engineering, conceptualized this idea as "paying it forward." He discussed that he had received invaluable help from other, often older or more experienced, SHPE students, and that he wanted to do the same for others.

> I wanted to help out and pay it forward so maybe there will be another kid down the line who due to my contributions will influence them to pursue something that as difficult as an engineering program here at [this university]. –Bob

Karina discussed the idea of being a role model to others as thinking about success beyond her. She commented that being part of SHPE and helping other students in SHPE propelled her to think beyond her individual success.

> I think it's made me more humble in the sense that it's not all just about you and that you can help other engineering students also prosper. So I initially started off my SHPE career very focused on just me ... mmm ... but toward the end of being a SHPE member I definitely became more humble and wanted to help other students also prosper. –Karina

Finding engineering role models for themselves, especially in SHPE, was also important in the students' engineering journeys and in their engineering identity development. Students found engineering role models in SHPE who helped them develop as engineers. The role models were usually older SHPE engineering students or SHPE alumni. For some students, being able to find other Latinas/os who were engineers or who were in pursuit of engineering degrees strengthened their identification with the field. Specifically, students valued finding other engineers “like them.” Manolo and Anthony describe the influence engineering role models within SHPE on their journeys.

> That [the older SHPE students’] motivation translated into their school as well, into them being engineering students, and to their professional development, and you could tell every single one of these people here, these guys are going to accomplish their education, accomplish their career. –Manolo

> I quickly started to see the benefits of SHPE ... most importantly hearing what other Latino engineers were like, and how they got there, hearing their story. –Anthony

This theme of engineering role modeling draws on the following two types of capital: navigational and aspirational.

Navigational capital. Through their role modeling, students used their navigational capital to navigate the climate at their universities as they moved through the engineering curriculum. Having these engineering role models as academic and social support was instrumental in the students’ engineering journeys. For example, Linda explained how she felt especially comfortable working with her SHPE peers on homework and projects for class,

> Just working with Hispanics, I think I feel a little more I guess comfortable speaking my mind or giving opinions or trying to solve a problem because I feel that there is not that pre-judgmental opinion of me. –Linda

Similarly, as these students served as engineering role models for other engineering students, they enacted their navigational capital. For example, Cosmo explained how he passed on his knowledge to help others navigate the engineering profession.

> I talked about how like last fall I was telling them, all the students that were going to the SHPE conference the first time, you know, how to act in an interview, how to approach a recruiter, how to give your elevator speech. Things not to do. Things to do. And examples of how I got interviews the first time even though I never got a job out of it, things of that sort. –Cosmo

As role models, students shared strategies with others to navigate their engineering curriculum. Similarly, through their role models, students learned and applied skills to navigate their engineering journeys.

Aspirational capital. Students enacted their aspirational capital was by maintaining high hopes, dreams, and aspirations through their engineering role models. Students were able to see their own life goals and dreams in those of their SHPE engineering role models. Being able to see themselves through their role models helped them to continue their own journeys in engineering. As recounted by Bob, he saw the possibility of his own academic journey in the success of other Latina/o engineers,

> I met the current SHPE members and it ranged from freshmen who were doing well to seniors to grad students that were doing well and I never, I knew that there was such a thing as maybe Latino grad students, but when I met certain people, that they already had jobs lined up or they had certain research related jobs lined up, then I was like "wow! it can be done." –Bob

Although some of the students reported meeting engineering role models locally at their universities, a lot of them also mentioned role models outside of their universities. Meeting role models outside of the university was enough to spark students' aspirational capital to continue in engineering. For example, Manolo talked about the potential of maintaining hopes and dreams through simply knowing that others like him could also succeed.

> I think it's given me a goal to work to because being a SHPE student I've a lot of other just amazing individuals in my own chapter and just at national events and so that's helped me develop my own personal goals of how I want to be as a professional, how I want to be as a student, and how I want to be as a friend and a mentor to other people. Because I've seen good examples, I think that's what it's done to me, it's given me some really great and probably some of the best examples. –Manolo

Theme 4: Nurturing an engineering *familia*

Within SHPE, students found more than friendship and collegiality: they found a *familia* (family or kin) of engineers. The students discussed a strong, family-like tie that connected them to their peers in SHPE. They described this *familia* as a "huge network" of people who want to see each other succeed. Students who used the term *familia* usually qualified it with SHPE *familia.* Hector described what being part of the SHPE *familia* meant for him,

> Being there for each other, you know, when things really [get] rough ... help each other out during that process too during that time. –Hector

Cesar used words like "brothers" and "sisters" to describe the close ties he had with his SHPE *familia*.

> They were like my brothers and sisters at the time so ... we took care of each other ... And then of course there is the *familia* aspect so you have, as soon as you join you have a huge network of people who want you to succeed and will help you succeed. –Cesar

Joaquin highlighted the importance of his SHPE advisor and how she had become part of his *familia.* Joaquin described his SHPE advisor as his "second mom."

> I would have to say my SHPE advisor at my university. She has been one of the biggest supports I've had, she has been like a second mom to me here. –Joaquin

Joaquin talked about an instance where in the middle of the night, he was caught driving through an ice storm, something he was not used to, and felt comfortable to call his SHPE advisor and ask for help.

In my observations at the national conference, the sense of being part of a *familia* was undisputable. Throughout the conference, students used the hashtag #SHPEFamilia on social media to show how they were experiencing the conference with their SHPE *familia*. Through the use of this hashtag, students shared pictures and memories of their time together at the conference. At a large gala dinner at which professionals and students received awards for their achievements, one of the presenters urged the attendees to use the hashtag to showcase the SHPE *familia.*

This theme draws upon the following two types of capital: familial, navigational, and social.

Familial capital. Students employed their familial capital when they incorporated peers in SHPE, with whom they were not related by blood, into their *familia.* The nurturing of a SHPE *familia* shows that the students conceptualized their family or kin beyond their bloodline, to include others who were part of SHPE. As seen in the representative quotations above, students referred to each other as brothers and sisters. SHPE advisers were also part of the students' *familia*, often taking the role similar to that of a parent or guardian. The local chapter, at their university or college, was a "home away from home" as described by Linda in the quotation below,

> It's [SHPE] a very close group that that, you know it's there to help you whenever you do need it. Like if you need help, if you say I want to become more involved with SHPE there is always opportunities to do that umm and it's, it's a source for you to like kind of have a home base or a home away from home. –Linda

One of the ways that students built these close and genuine connections with one another was through regular involvement through holding a role in their local chapter. For example, Mike II was involved with his executive board and through his involvement was able to nurture his SHPE *familia.*

> Outside of family, and outside of my girlfriend, just my SHPE *familia* so being a part of the e-board [executive board] you really get to know everyone else on the e-board so it just gives you an opportunity to bond when it comes to all these events and everything we do together so they might not be electrical engineers, they might not be engineers at all, but they're people that know you and people you trust and people that you can go to when you have a problem or just need help and that's a really big plus. –Mike II

Navigational capital. Students nurtured their navigational capital through their strong ties with their SHPE *familia*. Anthony said that having a *familia* within SHPE that helped him persist and navigate the engineering climate. In this case, having a *familia* helped students build their navigational capital. Through their strong ties and connections with one another, the students helped each other navigate through the climate in their institutions and programs of engineering.

> SHPE's always been there and everyone's made sure that, you know, as a minority we feel comfortable and that we succeed. –Anthony

Social capital. Students had access to local and national networks of people within SHPE that were instrumental for their development as engineers. Specifically, students spoke about the emotional support that their SHPE peers provided that helped them navigate their engineering career and develop as engineers. Anthony, explains the importance of the emotional support for his persisting in engineering,

> Just the conversations I've had talking with people and telling them how I felt and how sometimes I felt like I shouldn't be going to college and how I probably was gonna fail out and drop out and they were always like "No, everybody goes through this, there is people in SHPE that have been here for like 9 years, but it's okay you know, it doesn't matter how fast you finish." –Anthony

Though most of the students primarily commented on having emotional support to navigate engineering, they also mentioned advisor support. However, most of the advisors students mentioned were either their SHPE advisors or their Minority Engineering Program (MEP) advisors. Most of the students did not mention faculty advisors that were not related to SHPE or MEP.

Aside from having emotional support from peers and advisors, students also mentioned academic support that was nurtured in their SHPE *familia* and was important for their development as engineers. The majority of students mentioned SHPE as an academic support group that played a role in their development as engineers.

> A support group, I would say a support group 'cause you know we're all there, we all think alike, come from the same backgrounds most of us, and umm basically the support group you know we work together, do homework together, we have like homework

sessions umm we ask each other questions with homework or stuff that we don't understand so a support group I would say. –Luis

In summary, four themes were found from the interviews and observations in the first phase of this mixed methods study. These themes were 1) developing professional and leadership skills, 2) having an impact in the community, 3) being and finding engineering role models, 4) nurturing an engineering *familia*. These themes mapped to the six types of capital in Yosso's (2005) Community Cultural Wealth framework. Figure 4.1 shows the connections between the CCW framework and themes found in the first phase of this study.

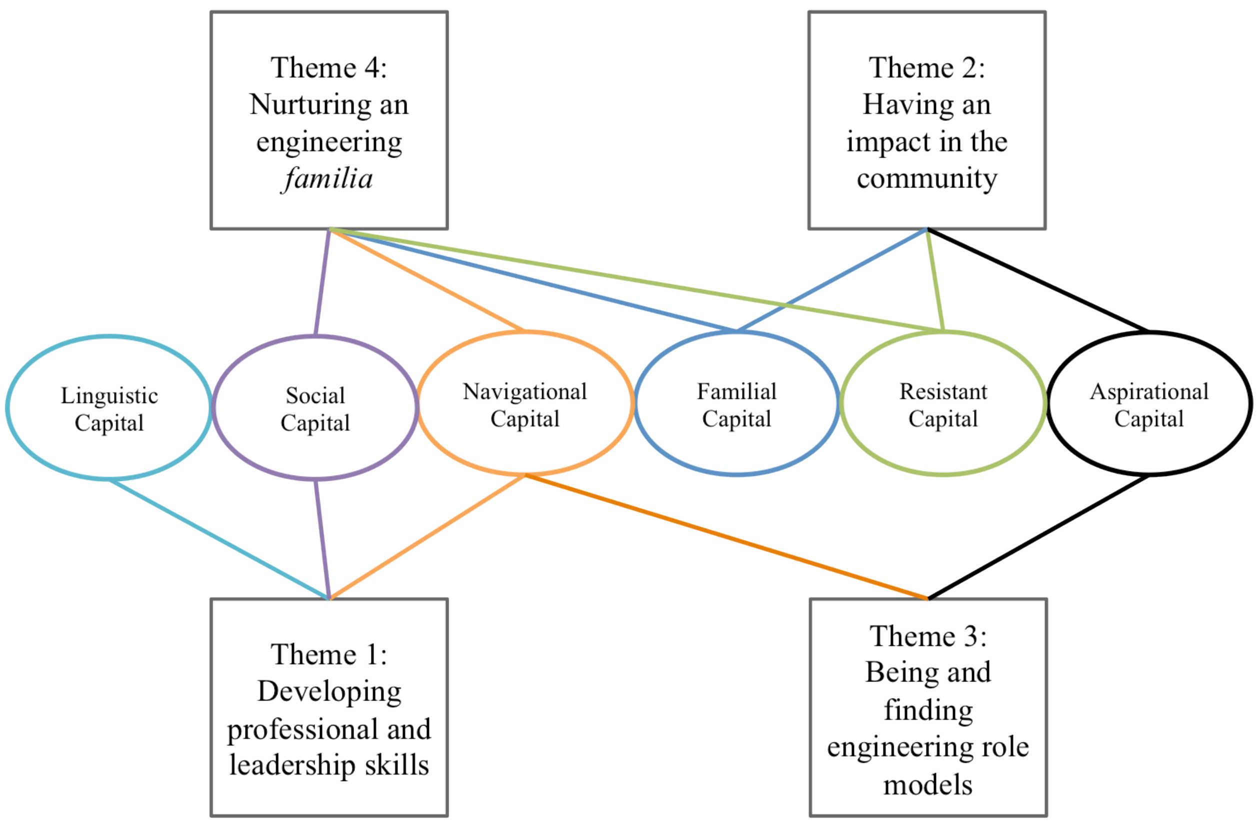

Figure 4.1: Theme connections to CCW capitals

Limitations

This study was limited to Latina/o members of SHPE. The experiences of SHPE members may not generalize to the experience of all Latina/o engineering students. While the goal of qualitative methods is not necessarily to generalize to a larger population, one of the ways to address the influence of SHPE membership on engineering identity development is through a follow up survey. The survey, developed in the second phase of this study, can be administered to Latina/o students who are not in SHPE.

The sample was limited to students who attended the 2013 national SHPE conference. Conference attendees may be more highly involved than their peers; on the plus side, these students are considered information-rich participants as the focus of this study is on influence of being members of SHPE, and attending the national conference is an important aspect of SHPE membership. The sample was also limited to self-selected students. Students who self-select may have had stronger reasons (positive or negative) to participate than students who did not participate.

One of the interview protocol shortcomings was in eliciting conversation about linguistic capital as it pertained engineering identity development. Only two questions were asked of the students regarding linguistic capital. These two questions led to responses about how language intersected with the students’ academic journeys, mostly signaling to the educational importance of growing up speaking Spanish. However, the interview questions did not elicit connections between language and engineering identity. Asking questions about students’ storytelling experiences and other forms of communication to talk about their development as engineers could strengthen the interview protocol.

CHAPTER 5

Quantitative Phase

A survey of engineering identity development was constructed using results from the first phase of the study. The interview and observation results from the first phase consisted of four themes, which I translated into survey constructs and items; this process was consistent with the overall developmental purpose of this mixed methods study to develop a new method. In this chapter, I will discuss survey item construction, data collection, data screening, participant demographics, exploratory factor analysis results, reliability analysis, and the final factor structure.

Item Construction

Keeping consistent with the purpose of development for this mixed methods study, the survey items were constructed using the results from the first phase. A developmental mixed methods study allowed me to construct an engineering identity development survey that was culturally situated on the students' engineering journeys.

The survey constructs, derived from the first phase, were commitment to community, developing as a professional and as a leader, engineering role modeling, and having an engineering *familia.* Survey items were developed for each of these constructs. Guided by the goal of creating a culturally situated survey of engineering identity development for Latina and Latino students, I used participant language and specific experiences to create survey items. As examples of participant language, I used the terms *familia* and SHPE *familia* instead of only asking about peers or support to honor the terminology that students used in the interviews. As an example of specific experiences, to explore the construct of commitment to community, I included in the survey a question about *noche de ciencias* ("science night" – an outreach science program for kids and parents) as a specific experiential example of commitment to community. I added previously developed survey items to measure intrinsic motivation from Sheppard et al. (2010). Though the interview protocol did not directly address motivation behind studying engineering, aspects of intrinsic motivation to study engineering were present in the ways students talked about their engineering journey in their interviews.

The constructs, construct definitions, and survey items that were used in the piloted survey are presented in Table 5.1. A 5-point Likert scale was used for all survey items. A copy of the survey that was distributed to students appears in Appendix G. The final survey consisted 48 total questions, 33 of those questions were engineering identity development items, and 15 were demographic questions. Demographic questions 47 and 48 were borrowed from Pérez (2012).

Table 5.1
Engineering identity survey items and constructs

Construct	Construct Definition	Survey Items
Motivation	Intrinsic psychological and behavioral motivation to study engineering. These items were borrowed from Sheppard et al. (2010)	6. How good do you feel when you are doing engineering? 7. How fun do you think engineering is? 8. How interesting do you think engineering is? 9. To what extent do you like to build stuff? 10. To what extent do you like to figure out how things work?
Commitment to the community	Ties and commitment to the community through outreach and service	11. As an engineer, how important is giving back to the community through outreach such as *Noche de Ciencias* (Science Night)? 12. To you, how important are STEM outreach programs for kids? 13. As an engineer, how important is being involved in your community to you? 14. As an engineer, how committed are you to the wellbeing of your community?

Table 5.1 (cont.)

Developing as a professional	Skills learned through workshops and activities as a member of SHPE	15. To what extent has your participation in SHPE helped you develop as a professional? 16. To what extent have you acquired non-technical, professional skills from SHPE that you need to become an engineer? 17. To what extent have you attended SHPE workshops to learn about nontechnical, professional skills that you need to become an engineer? 18. To what extent have you developed your nontechnical, professional skills through your SHPE involvement? 19. To what extent has your participation in SHPE helped you develop communication skills to network with other professionals?
Developing as a leader	Skills learned through workshops or leadership roles held as a member of SHPE	20. To what extent has your participation in SHPE helped you develop as a leader? 21. As an engineer, how important is developing as a leader to you? 22. To what extent has your participation in SHPE helped you acquire leadership skills that you need to be an engineer? 23. To what extent have you attended SHPE workshops to learn about leadership skills that you need to be an engineer? 24. To what extent have you been able to take on leadership roles in SHPE that you need to be an engineer?
Engineering role modeling	Having and being an engineering role model to prospective and current engineering students	25. In your journey as an engineer, how important is finding engineering role models within SHPE? 26. In your journey as an engineer, how important is being able to find engineering role models? 27. In your journey as an engineer, how important is being an engineering role model to other engineering students?

Table 5.1 (cont.)

		28. In your journey as an engineer, how important is being an engineering role model to middle school and high school students? 29. In your journey as an engineer, how important is helping other engineering students prosper? 30. In your journey as an engineer, how important is having an engineer role model? 31. How important is it to you to have younger engineering students look up to you? 32. To what extent do you look for engineering role models in SHPE?
Having an engineering *familia*	Support and recognition from peers within SHPE and a familial type of relationship	33. To what extent do you feel like you have a *familia* (family) of engineers within SHPE? 34. To what extent do your peers in SHPE recognize you as an engineer? 35. How important is to have a SHPE *familia* (family) of engineers to you? 36. How important is having support from other Latina/o engineers to you? 37. To what extent do you feel like you are part of a *familia* (family) when you are around Latina and Latino engineers? 38. To what extent does seeing other Latina/o engineers succeed make you feel like you can succeed in engineering?

Data Collection

I collected the survey data using SurveyMonkey®. With the support of the national SHPE office, an email invitation was sent to undergraduate members of SHPE who were planning to graduate in 2015. Students graduating in 2015 were chosen for the pilot survey so as to not over-survey potential participants in a future distribution of the final survey. The email invitation was sent to 1,629 students through SHPE's SHPEConnect message system; about half of the students opened the first email message. After the first email message was sent, there were three email reminders sent to students. There was a low response of 47 respondents after two weeks of sending the first email invitation and subsequent reminders; as a result, a second, targeted invitation was sent to the presidents of student chapters to distribute the survey invitation to their respective membership. In an attempt to ensure students received the first email invitation, the second invitation was sent only to presidents of student chapters for students who were sent the first email invitation. In total, there were 105 responses at the closing of data collection.

Data Screening

I followed standard procedures outlined in Tabachnick and Fidell (p. 89, 1989) to screen data prior to analysis. Specifically, data screening involved checking for missing data, outliers, normality, singularity, and multicollinearity. The original dataset included 105 unique survey responses or cases.

Missing Data

Cases were removed from the analysis for three reasons. First, cases that were missing values for the majority of survey items were removed. There were thirteen cases that fit this criterion and as a result were removed from the original dataset. These cases had too much incomplete data and were not suitable for missing data imputation. Second, and in keeping consistent with the research question, cases for respondents who answered "No" to item number 46 about identifying as Latina/o, Chicana/o, or Hispanic were removed. Seven cases were removed for this reason. Finally, and also in keeping consistent with the research question, cases for respondents who did not consider themselves engineers (by checking only "I do not consider myself an engineer" to item 5) or who considered themselves only as scientist (by only checking "I consider myself a scientist" to item 5) were removed from the dataset. Four cases were removed for this reason. Overall, 24 cases were removed from the original data set because they met at least one of three criteria.

The majority of the 81 cases remaining had complete data. Of the 81 cases that remained, one case had three missing values, one case had two missing values, and nine cases had one missing value each. In total, there were 14 missing values across 11 cases that had partly complete data. Because there were no patterns in the missing values, I estimated the missing values for each case using the mean of the item (Tabachnick & Fidell, 1989). In summary, checking for missing data resulted in the removal of 24 cases. At the end of this step, there were 81 unique cases in the dataset.

Univariate and Multivariate Outliers

The next step in the data screening process was to detect univariate and multivariate outliers. Univariate outliers are cases with an extreme value on one variable; multivariate outliers are cases with extreme values on more than one variable. To check for univariate outliers, I calculated the standardized scores, z scores, for all the cases. Z scores were calculated using the mean and standard deviation for each item to center the value of each case on the mean of each item. Cases that had z scores greater than the absolute value of 3.29 ($p < 0.001$) on any one item were considered univariate outliers because they would be highly unlikely to occur. As a result, cases with z scores greater than the absolute value of 3.29 were removed from the dataset (Tabachnick & Fidell, 1989). Six cases met the univariate outliers threshold. Similarly, multivariate outliers were detected using the Mahalanobis distance for each case. A case with a Mahalanobis distance greater than the critical value for the Mahalanobis distance is considered a multivariate outlier (Tabachnick & Fidell). For this dataset, the critical value for the Mahalanobis distance with alpha .001 and degrees of freedom of 33 (number of survey items) is the chi-square score of $\chi^2 = 63.87$. No cases had a Mahalanobis distance greater than $\chi^2 = 63.87$; thus there were no multivariate outliers found in the dataset.

Normality

The next step in the data screening process was to check for normality in the items. To test for normality, I calculated the skewness and kurtosis of each item. Skewness and kurtosis were assessed by checking for items that had absolute values of skewness greater than 2 and kurtosis greater than 7 (West, Finch, & Curran, 1995). The results are shown in Table 5.2. None of the items had excess skewness or kurtosis and thus all the items passed the normality test.

Table 5.2
Item Normality Test

Item Number	Skewness	Kurtosis
6	-0.28	2.08
7	-0.34	2.22
8	-1.00	2.98
9	-1.04	4.19
10	-1.00	2.93
11	-0.98	3.00
12	-1.75	6.17
13	-1.56	5.77
14	-0.99	4.06
15	-0.76	2.90
16	-0.79	2.85
17	-0.75	2.89
18	-1.10	3.82
19	-0.52	2.29
20	-1.01	3.16
21	-1.73	5.57
22	-0.83	3.05
23	-0.60	2.53
24	-0.56	2.32
25	-0.89	3.51
26	-0.73	2.42

Table 5.2 (cont.)

27	-0.55	2.35
28	-1.20	4.59
29	-0.55	2.40
30	-1.47	5.41
31	-1.12	4.10
32	-0.38	2.36
33	-1.20	3.70
34	-0.85	4.65
35	-0.96	3.22
36	-1.07	3.49
37	-1.06	3.34
38	-1.23	4.26

Singularity and Multicollinearity

The final step in data screening was to check for singularity and multicollinearity. These problems occur when the variables are too highly correlated (Tabachnick & Fidell, 1989). To check for singularity and multicollinearity, I used Pearson's correlation to look for any correlations that were higher than 0.9. Upon inspection of the correlation matrix, I found that there were no data that were multicollinear or singular.

After completion of data screening, 75 cases were left in the dataset with no missing values and fourteen imputed values.

Factorability of the Correlation Matrix

Two final tests were performed to check the factorability of the correlation matrix. The first test was the Kaiser-Meyer-Olkin measure of sampling adequacy (Kaiser, 1974). Values of 0.6 and above are required for good factor analysis (Tabachnick & Fidell, 1989). The overall measure of sampling adequacy was 0.79 indicating that the correlation matrix was factorable. The second test performed to check the factorability of the correlation matrix was the Bartlett's test of sphericity. Bartlett's test of sphericity is a test of significance to check that the correlations in a correlation matrix are not zero. This test is specifically recommended if there are fewer than five cases per survey item (Tabachnick & Fidell). The null hypothesis that the correlations are zero was rejected ($\chi^2 = 1595.1$, df=528 with $p<0.001$). Thus, it is very unlikely that the matrix is diagonal. The correlation matrix passed both tests of factorability and as a result no variables were dropped. Given that the correlation matrix is factorable, the next step is to perform exploratory factor analysis and arrive at a simple factor structure.

Exploratory Factor Analysis

I used Exploratory Factor Analysis (EFA) to test the construct validity of the survey developed using the qualitative data from the first phase. The EFA procedures outlined in Tabachnick and Fidell (1989) were used for this analysis. The remainder of this section covers these procedures and the EFA results.

Number of Factors to Extract

One of the first and critical steps in EFA is determining the number of factors to extract. To determine the number of factors to extract, I used the following criteria: eigenvalues, cumulative variance, and a scree plot (Tabachnick & Fidell, 1989). An eigenvalue represents the amount of variance accounted for in a factor. Factors with eigenvalues greater than one account for more than a single item; as a result components that have eigenvalues less than one are discarded from analysis (Costello & Osborne, 2005). Through an initial principal components analysis, I obtained the cumulative variance of factors and eigenvalues. The first eight components had eigenvalues greater than 1. In educational research, typical cumulative variance of factors can range from 50% to 90% (Beavers, Lounsbury, Richards, Huck, Skolits, & Esquivel, 2013). Upon inspection of principal components analysis, I found that the first five components explained 65% of the cumulative variance, with only a less than 4% increase after the fifth component. Finally, I examined the scree plot, which has the eigenvalues on the y-axis and the components on the x-axis (Cattell, 1966). A straight line that can comfortably fit the components with the smallest eigenvalues is drawn to rule out components that account for the least variance in the data. The remaining components are retained. There were five factors that were retained by using the scree plot test. Using these criteria, results from the first phase, and criteria for educational research (Beavers et al., 2013), I retained five final factors.

Principal Axis Factoring with Oblimin Rotation

I ran Exploratory Factor Analysis (EFA) using R Studio with five factors retained. I chose Principal Axis Factoring (PAF) in order to maximize the variance extracted by the factors (Tabachnick & Fidell, 1989). Practically, PAF was also chosen in order to examine the shared variance among variables in the dataset through a small number of factors (Warner, 2013). Oblique rotation was chosen to rotate the factors for two reasons. First, inspection of the factor correlation matrix revealed that two factors were highly correlated (.76). Second, oblique rotation is recommended for social science research where factors are more likely to be correlated in practice (Beavers et al., 2013). As recommended by Beavers et al. for education research, I chose oblimin rotation, which simplifies the factor structure by minimizing cross products of loadings (Tabachnick & Fidell).

Various standard procedures were followed to clean up the initial factor structure. Before extracting and interpreting the factors, I inspected the extracted communalities. The extracted communality of a variable represents the amount of variance that is predictable from the factors underlying it (Tabachnick & Fidell, 1989). Variables with a low communality were considered outliers and were taken out of the final factor structure one at a time. Items 21 and 31 were removed from the dataset due to their low communalities (less than 0.2). Tests of factorability, namely KMO and Bartlett's, remained valid after removal of each of these variables. To further clean up the factor structure, items that did not strongly load on any factor were removed. Item 29 was the only one that did not load on any factor and was removed. Finally, cross-loading items were removed. Cross-loading items are those that load on more than one factor. Tabachnick and Fidell suggest only keeping cross-loading items that have loading values less than .32. Costello and Osborne (2005) further suggest removing items that load at 0.5 or above for more than one factor. After inspection of the factor structure and using these guidelines for cross-loading items, I removed item 32. Finally, items 27, 33, and 34 were removed because they loaded (poorly) only on the wrong factor. In total, seven items (i.e., items 21, 27, 29, 31, 32, 33, and 34) were removed from the original survey of 33 items.

Participant Data

This section briefly summarizes the participant data in the finalized dataset used for EFA. The final dataset consisted of 75 respondents. The gender breakdown for survey participants was 47% female, 52% male, and 1% who did not respond. About 77% of the participants were fourth or fifth year undergraduates. The majority of participants were non-transfer students (64%). They represented a range of engineering majors; the top five majors were mechanical engineering, civil engineering, aerospace engineering, chemical engineering, and industrial engineering. Almost all participants identified as Latina/o, Chicana/o, or Hispanic (92%), 8% of the participants identified as Latina/o, Chicano/o, or Hispanic sometimes, and one participant was unsure. With regard to ethnicity, the top four ethnic backgrounds that participants identified with were Mexican, Puerto Rican, Ecuadorian, and Colombian. Nineteen participants had family members, other than their parents or siblings, who were engineers. Eight of the participants knew engineers through their high school teachers. With regard to the highest level of a parent's education, 19% of the participants responded that the highest level of education for a parent was a High School Diploma or GED followed by a 16% for Bachelor's degree. With regard to SHPE, about 41% of the participants were involved with SHPE for 3-4 years. The majority (56%) were executive board members. These participant demographics are summarized in Table 5.3

Table 5.3
Survey Participant Demographics

Category	Sub-Category	Freq. (%)
Gender	Female	35 (47%)
	Male	39 (52%)
	Did not respond	1 (1%)
Undergraduate Year	1st year	1 (1%)
	2nd year	4 (5%)
	3rd year	7 (9%)
	4th year	35 (47%)
	5th year	22 (29%)
	6 or more years	6 (8%)
Transfer / Non-Transfer	Transfer	27 (36%)
	Non-transfer	48 (64%)
Top Five Majors	Mechanical engineering	22 (29%)
	Civil engineering	16 (21%)
	Aerospace engineering	9 (12%)
	Chemical engineering	8 (11%)
	Industrial engineering	6 (8%)
Top Eight Ethnic Backgrounds	Mexican	33 (44%)
	Puerto Rican	11 (15%)
	Ecuadorian	8 (11%)
	Colombian	6 (8%)
	Cuban	3 (4%)
	Guatemalan	3 (4%)
	Salvadorian	3 (4%)
	Venezuelan	3 (4%)
Family Engineers	Mother	1 (1%)
	Father	8 (11%)
	Siblings	7 (9%)
	Other family members	19 (25%)
Highest Level of Parents Education	Some high school	8 (11%)
	High school diploma or GED	14 (19%)
	Some college	12 (16%)

Table 5.3 (cont.)

	Bachelor's degree	12 (16%)
	Master's degree	7 (9%)
	Doctoral degree	7 (9%)
Years in SHPE	Less than 1 year	14 (19%)
	1-2 years	21 (28%)
	3-4 years	31 (41%)
	More than 4 years	9 (12%)
	General Member	64 (85%)
Roles held in SHPE	Executive Board Member	42 (56%)
	Freshman Executive Board Member	7 (9%)
	Jr. SHPE Member	6 (8%)
	National Representative	3 (4%)

With regard to considering oneself an engineer, the students were given four statements and they could choose any combination of these statements. These statements were "I consider myself an engineer," "I consider myself an aspiring engineer or an engineer in-training," "I consider myself a scientist," and "I do not consider myself an engineer." Seventy six percent (n=57) of the participants considered themselves engineers in training, 56% (n=32) of those participants considered themselves only engineers in training. In other words, those 32 participants picked only the statement "I consider myself an aspiring engineer or an engineer in-training." Forty-four percent (n=33) of participants considered themselves engineers, 36% (n=12) of those participants considered themselves only engineers. Twenty percent (n=15) of participants considered themselves both engineers and engineers in training. Note that the percentages may not add to one hundred because the participants had the option of choosing more than one statement. These participant data are summarized in Table 5.4.

Table 5.4
Participant data on considering oneself engineer

Category	Freq. (%)
Engineer	33 (44%)
Engineer in training	57 (76%)
Engineer & engineer in training	15 (20%)

Towards the end of the survey, participants answered various questions about their pre-college experiences with regard to engineering. About 51% of the participants knew engineers before college. About 65% of the participants knew about engineering before college. About 27% of participants were involved in an academic summer or after-school STEM program. Only two participants shadowed an engineer. With regard to engineering and computer science high school courses, 16% and 12% of participants took these high school courses respectively. Eighteen participants (24%) did not know about engineering before college, were not involved in an academic STEM program, did not shadow an engineer, and did not take engineering or computer science courses. These participant pre-college experiences are summarized in Table 5.5.

Table 5.5
Pre-college participant experiences

Statement	Freq. (%)
Knew engineers	38 (51%)
Knew about engineering	49 (65%)
Involved in an academic STEM program	20 (27%)
Involved in an extracurricular engineering program	14 (19%)
Shadowed an engineer	2 (3%)
Took engineering courses in high school	12 (16%)
Took computer science courses in high school	9 (12%)

Exploratory Factor Analysis Results

The final simple factor structure consisted of five factors and twenty-six items. Factor 1 consisted of items 6, 7, 8, 9, and 10 from the original survey. Factor 1 had a Cronbach’s alpha reliability coefficient of α = 0.74. Factor 2 consisted of items 11, 12, 13, 14, and 28 with α = 0.77. Factor 3 consisted of items 15, 16, 17, 18, 19, 20, 22, 23, 24 with α = 0.94. Factor 4 consisted of items 25, 26, and 30 with α = 0.75. Factor 5 consisted of items 35, 36, 37, and 38 with α = 0.85. The final simple factor structure had a Cronbach's alpha reliability coefficient of α = 0.91. The final simple factor structure, with the survey item numbers from the distributed survey, is shown in Table 5.6. Table 5.7 shows the factor correlation matrix.

Table 5.6
Simple Factor Structure using Principal Axes Factor Analysis with Oblimin Rotation (α = 0.91)

	Factor Loadings				
Survey Items	1	2	3	4	5
Factor 1: Intrinsic and psychological motivation to study engineering (α = 0.74)					
6. How good do you feel when you are doing engineering?	0.66				
7. How fun do you think engineering is?	0.71				
8. How interesting do you think engineering is?	0.71				
9. To what extent do you like to build stuff?	0.43				
10. To what extent do you like to figure out how things work?	0.35				
Factor 2: Commitment to the community (α = 0.77)					
11. As an engineer, how important is giving back to the community through outreach such as *Noche de Ciencias* (Science Night)?		0.79			
12. To you, how important are STEM outreach programs for kids?		0.38			
13. As an engineer, how important is being involved in your community to you?		0.71			
14. As an engineer, how committed are you to the well being of your community?		0.64			
28. In your journey as an engineer, how important is being an engineering role model to middle school and high school students?		0.36			

Table 5.6 (cont.)

Factor 3: Professional and leadership development through SHPE (α = 0.94)			
15. To what extent has your participation in SHPE helped you develop as a professional?	0.75		
16. To what extent have you acquired nontechnical, professional skills from SHPE that you need to become an engineer?	0.72		
17. To what extent have you attended SHPE workshops to learn about nontechnical, professional skills that you need to become an engineer?	0.74		
18. To what extent have you developed your non-technical, professional skills through your SHPE involvement?	0.93		
19. To what extent has your participation in SHPE helped you develop communication skills to network with other professionals?	0.84		
20. To what extent has your participation in SHPE helped you develop as a leader?	0.91		
22. To what extent has your participation in SHPE helped you acquire leadership skills that you need to be an engineer?	0.86		
23. To what extent have you attended SHPE workshops to learn about leadership skills that you need to be an engineer?	0.76		
24. To what extent have you been able to take on leadership roles in SHPE that you need to be an engineer?	0.58		
Factor 4: Engineering role modeling (α = 0.75)			
25. In your journey as an engineer, how important is finding engineering role models within SHPE?		0.34	
26. In your journey as an engineer, how important is being able to find engineering role models?		0.77	
30. In your journey as an engineer, how important is having an engineer role model?		0.75	
Factor 5: Engineering *familia* (kin or family) (α = 0.85)			
35. How important is to have a SHPE *familia* (family) of engineers to you?			0.56

Table 5.6 (cont.)

36. How important is having support from other Latina/o engineers to you?		0.99
37. To what extent do you feel like you are part of a *familia* (family) when you are around Latina and Latino engineers?		0.45
38. To what extent does seeing other Latina/o engineers succeed make you feel like you can succeed in engineering?	0.32	0.63

Note: loadings < 0.32 are suppressed

Table 5.7
Factor Correlation Matrix

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Factor 1	1				
Factor 2	0.34	1			
Factor 3	0.37	0.10	1		
Factor 4	0.27	0.32	0.24	1	
Factor 5	0.28	0.33	0.13	0.33	1

There were minor problems with an otherwise simple factor structure that may have been a result of the limited sample size. One of the items, number 38, cross-loaded with two factors; the item was kept in the final structure nonetheless because the cross-loading was exactly at the cut-off level (0.32) and the item loaded adequately with the predicted factor. Item number 28 was predicted to load with Factor 4 and instead it loaded with Factor 2. Upon inspection of the construct for Factor 2, Commitment to the Community, and results from the first phase of the study, I decided to keep item number 28 with Factor 2. Item number 28 asked about being a role model to middle school and high school students. Through this role modeling activity, students were able to have an impact in the community. As a result, item number 28, though initially designed for Factor 4, was subsumed into Factor 2.

Item and Reliability Analysis

Item and reliability analysis were performed to assess the final factor structure. Tables 5.8 and 5.9 show the results from this analysis. Table 5.8 shows the item mean, standard deviation, item-total correlation, and the reliability coefficient if the item was deleted. Item-total correlation captures the correlation between each item and the total score for the factor. All item-total correlations were above 0.4 showing that each item correlated well with other items in the same factor. None of the items increased the reliability coefficient when dropped for factors 1, 3, and 5. For factor 2, the reliability coefficient would increase by 0.003 if item number 28 was dropped. Because the increase was small, the item was kept in the final structure. For factor 4, the reliability coefficient would increase by 0.082 if item number 25 was dropped. Item number 25 was kept in the final structure because removal of this item would have reduced factor 4 to two items.

Table 5.8
Item Analysis Results

	Mean (SD)	Item-Total Correlation	Alpha if Item Deleted
Factor 1: Intrinsic and psychological motivation to study engineering			
6. How good do you feel when you are doing engineering?	4.20 (0.72)	0.52	0.69
7. How fun do you think engineering is?	4.32 (0.64)	0.58	0.66
8. How interesting do you think engineering is?	4.63 (0.56)	0.62	0.66
9. To what extent do you like to build stuff?	4.29 (0.75)	0.42	0.73
10. To what extent do you like to figure out how things work?	4.56 (0.62)	0.41	0.73
Factor 2: Commitment to the community			
11. As an engineer, how important is giving back to the community through outreach such as *Noche de Ciencias* (Science Night)?	4.33 (0.81)	0.71	0.67
12. To you, how important are STEM outreach programs for kids?	4.67 (0.53)	0.48	0.76
13. As an engineer, how important is being involved in your community to you?	4.45 (0.68)	0.60	0.72
14. As an engineer, how committed are you to the well being of your community?	4.19 (0.78)	0.57	0.73

Table 5.8 (cont.)

28. In your journey as an engineer, how important is being an engineering role model to middle school and high school students?	4.44 (0.66)	0.40	0.78
Factor 3: Professional and leadership development through SHPE			
15. To what extent has your participation in SHPE helped you develop as a professional?	4.17 (0.83)	0.78	0.93
16. To what extent have you acquired non-technical, professional skills from SHPE that you need to become an engineer?	3.87 (1.11)	0.71	0.93
17. To what extent have you attended SHPE workshops to learn about nontechnical, professional skills that you need to become an engineer?	3.82 (1.11)	0.73	0.93
18. To what extent have you developed your non-technical, professional skills through your SHPE involvement?	3.96 (1.06)	0.86	0.93
19. To what extent has your participation in SHPE helped you develop communication skills to network with other professionals?	3.92 (1.05)	0.80	0.93
20. To what extent has your participation in SHPE helped you develop as a leader?	4.01 (1.11)	0.86	0.93
22. To what extent has your participation in SHPE helped you acquire leadership skills that you need to be an engineer?	3.95 (1.03)	0.85	0.93
23. To what extent have you attended SHPE workshops to learn about leadership skills that you need to be an engineer?	3.61 (1.11)	0.78	0.93
24. To what extent have you been able to take on leadership roles in SHPE that you need to be an engineer?	3.67 (1.24)	0.59	0.94
Factor 4: Engineering role modeling			
25. In your journey as an engineer, how important is finding engineering role models within SHPE?	4.08 (0.91)	0.47	0.83
26. In your journey as an engineer, how important is being able to find engineering role models?	4.44 (0.66)	0.63	0.64
30. In your journey as an engineer, how important is having an engineer role model?	4.43 (0.76)	0.69	0.54
Factor 5: Engineering *familia* (kin or family)			
35. How important is to have a SHPE *familia* (family) of engineers to you?	4.24 (0.85)	0.70	0.80

Table 5.8 (cont.)

36. How important is having support from other Latina/o engineers to you?	4.28 (0.86)	0.81	0.75
37. To what extent do you feel like you are part of a *familia* (family) when you are around Latina and Latino engineers?	4.19 (0.98)	0.65	0.82
38. To what extent does seeing other Latina/o engineers succeed make you feel like you can succeed in engineering?	4.41 (0.77)	0.60	0.84

Table 5.9 shows descriptive statistics results that illustrate the distribution for the factors are approximately normal. The mean score for each factor was calculated by dividing the mean score for each factor by the number of items in the factor because all of the factors had a 5-point scale.

Table 5.9
Descriptive Statistics for Final Factors

Factor	No. of items	Mean (SD)	Skew	Kurtosis	Alpha
Factor 1	5	4.40 (0.46)	-0.50	-0.36	0.74
Factor 2	5	4.42 (0.51)	-0.59	0.40	0.77
Factor 3	9	3.89 (0.88)	-0.92	0.55	0.94
Factor 4	3	4.31 (0.64)	-0.92	0.85	0.75
Factor 5	4	4.28 (0.72)	-0.75	-0.44	0.85

Description of Factors

The five following factors were present in the final factor structure: intrinsic and psychological motivation to study engineering, commitment to the community, professional and leadership development through SHPE, engineering role modeling, and engineering *familia*. These factors represent the constructs that guided the development of the survey. Results from EFA confirm the existence of these factors for this pilot survey.

The first factor, intrinsic and psychological motivation to study engineering, assessed a student's motivation to study engineering. The items for this factor were developed by Sheppard et al. (2010). The items borrowed from Sheppard et al. (2010) ask about how fun and interesting engineering is, how good the student feels when doing engineering, and how the student likes to build stuff and figure out how stuff works. The intrinsic and psychological motivation items were included because they were present in the experiences of the interviewed students. The interviewed students expressed being motivated to study engineering because they were intrinsically motivated (e.g., they liked math/science/computers, they had a "thirst for knowledge").

The second factor, commitment to the community, assessed the student's commitment to the community especially through outreach with younger students. The questions were phrased to situate commitment to the community within the context of developing as an engineer. The items for this factor addressed the importance of giving back to the community and being involved in the community. Guided by the Community Cultural Wealth framework, item 14 asked students about their commitment to the well being of their community. Item 11 specifically asked about the outreach program, *noche de ciencias* (science night), because it was a common example that interviewed students used.

The third factor, professional and leadership development through SHPE, assessed the importance students placed on developing professional and leadership skills, especially through SHPE. The results from the first phase showed that students developed these skills by attending workshops and taking on leadership roles within the organization. In the construction of the survey items, development as a professional and development as a leader were constructed separately. EFA revealed that these two constructs are better understood as one. The common denominator for understanding these two constructs together may be the role that SHPE plays.

The fourth factor, engineering role modeling, assessed the importance of having and finding engineering role models. One item for this factor asked specifically about finding role models within SHPE. The importance of having and finding engineering role models was prevalent in discussion with students interviewed in the first phase of this study. Items 27, 29, 31, and 32 were removed from this construct because they did not load strongly with the factor.

The fifth factor, engineering *familia*, assessed the importance of having a family-like network of engineers. The term *familia* was used in two of the items for this factor. This term emerged from interviews with students in the first phase of this study where students talked about the kin or family –like the relationship they had with peers within SHPE. Other items for this factor asked about having support from other Latina/o engineering students and engineers, feeling part of a family, and seeing one's success in the success of other Latina/o engineers.

Survey Use

The goal of this mixed methods study was to develop an engineering identity survey that was culturally situated in the experiences of Latina/o students. Aside from providing a culturally situated understanding of engineering identity, this survey could be used in institutions of higher education. Colleges and departments can use this survey to obtain an understanding of their Latina/o engineering student population. Specifically, researchers, administrators, and faculty can use the results from this survey to address how students can be best supported in their engineering journey and engineering identity development. As an example, students who highly value commitment to the community, as measured by the commitment to community construct, can be selectively invited to programs or courses that meet that need. The survey can also be administered longitudinally to see how students are being supported in their development as engineers as they move through the engineering curriculum.

The results from this survey can also aid in understanding the type of impact student organizations have on a student's engineering identity development. As an example, when survey results show that students use student organizations to develop as professionals and leaders, administrators and faculty can justify support for these student organizations. This support may be especially important for organizations that are primarily led and run by students. Structured support by engineering programs could help students to have an integrated engineering identity development. In other words, the student can be purposefully supported in their growth as an engineer inside and outside of the student organization.

Finally, the results from this survey can be used to inform the creation of programs that support students in their engineering identity development. While existing programs may help students develop as engineers, results from the survey can help to assess strategic development or changes to programs to better align program goals with engineering identity development for Latina/o students.

Limitations

One of the shortcomings of the exploratory factor analysis is the sample size. Tabachnick and Fidell (1989) recommend a sample size of at least 100 cases for EFA, but researchers have proposed other ways to assess the adequacy of sample size. One way to assess the adequacy of sample size is through use of subject to item ratio. Though having at least 10 cases per item in the survey has been recommended (Costello & Osborne, 2005), more recent review of the factor analysis literature for educational research disputes that case to item ratio as an accurate guideline (Beavers et al., 2013). Beavers et al. argue that for factor structures with more than four items per factor loading at 0.6 or higher, the sample size is irrelevant. Otherwise, a sample size of at least 150 is needed EFA. For future development of this instrument, an *a-priori* target sample size for EFA and confirmatory factor analysis should be used using relevant criteria.

CHAPTER 6

Discussion, Implications, & Conclusion

Despite the efforts in the last forty years, Latina/o undergraduates continue to be underrepresented in engineering (Chapter 1). Research has shown that engineering students are more likely to persist if they identify as engineers during their college years (Beam, Pierrakos, Constantz, Johri, & Anderson, 2009; Pierrakos, Beam, Constantz, Johri, & Anderson, 2009). One way to study identification with engineering is through the study of engineering identity development. Because most surveys of engineering identity have not been developed for students of color, they may not provide a culturally situated understanding of engineering identity development for these students (Chapter 2). The goal of this study was to develop a survey of engineering identity for Latina/o students. To achieve this goal, I used a mixed methods development approach (Greene, 2007) with two phases (Chapter 3). In both phases of the study, I used an asset-based approach to investigate the engineering journeys of self-identified Latina/o undergraduate members of the Society of Hispanic Professional Engineers (SHPE). To employ an asset-based approach, I used Yosso's (2005) community cultural wealth framework. This framework enabled me to identify and document the wealth "to transform education and empower People of Color to utilize assets already abundant in their communities" (p. 89). Through interviews and observations in the first phase of this study, I described the knowledges and capital that students utilized in their engineering journeys (Chapter 4). Using the results from the interviews and observations, I created a survey of engineering identity development for Latina/o students in the second phase. The survey was piloted and checked for construct validity and reliability (Chapter 5).

Summary of Findings

The summary of findings outlined below include findings from the first and second phases as a preliminary attempt to integrate analysis of both sets of data (Greene, 2007, p. 102). A similar analysis can be performed using data from a future distribution of the finalized survey. The following research question was answered in both phases of the study: In what ways and to what extent does membership in the Society of Hispanic Professional Engineers influence the engineering identity development of Latina and Latino students?

Integrated Finding 1: About half of the students did not know engineers before college. Only 50% of the interviewed students and 51% of the surveyed students knew engineers before college. The vast majority of students did not have parents who were engineers. Only 10% of interviewed students interviewed and 12% of surveyed students had parents who were engineers. Although women are significantly more likely to have engineering parents (Chanderbhan-Forde, Heppner, & Borman, 2012; Mannon & Schreuders, 2007), there was no statistical difference between the proportions of engineering parents for Latinas and Latinos in the surveyed sample. Students who persist in engineering have more exposure to engineering through parents compared to those who switch out of engineering (Pierrakos, Beam, Constantz, Johri, & Anderson, 2009). Martin, Simmons, and Yu (2013) found that for Hispanic women the social capital needed to select engineering as a major was supplemented by high school teachers and counselors. Only a minority of interviewed and surveyed students learned about engineering through their high school teachers or counselors. In fact, 24% of surveyed students did not have any of the exposure to engineering mentioned above before college.

Integrated Finding 2: The majority of students identified themselves as engineers or engineers in training. For the interviewed students, 60% considered themselves engineers and

30% considered themselves engineers in training. For the survey, students were able to select more than one identification statement. Forty-four percent considered themselves engineers; 76% considered themselves engineers in training. Identification with and by engineering is an important part of developing as an engineer (Stevens, O'Connor, Garrison, Jocuns, & Amos, 2008). For some students, a diploma or completion of the engineering degree may be necessary before they can considered themselves engineers (Loui, 2005; Meyers, Ohland, Pawley, Silliman, & Smith, 2012); however, students in this study considered themselves engineers nevertheless. Integrated finding 2 is consistent with Fleming, Smith, Chivon, Williams, and Bliss (2013) that in the way that students conceptualized their engineering identity, being an engineering student equaled being an engineer. Interestingly, while Meyers, Ohland, Pawley, Silliman, and Smith (2012) found that males were more likely to identify as engineers than females; however, I found that the surveyed Latina students were just as likely to identify as engineers as the Latino students.

Integrated Finding 3: Students defined engineers as problem solvers. This finding is consistent with engineering identity literature that positions problem solving as central to the definition of engineering (Chachra, Kilgore, Loshbaugh, McCain, & Chen, 2008; Pierrakos, Beam, Watson, Thompson, & Anderson, 2010) or as part of a profile of an engineer (Davis, Beyerlin, & Davis, 2005).

Integrated Finding 4: As found through interviews and exploratory factor analysis, some students were intrinsically motivated to pursue engineering as a career. Interviewed students expressed their motivation as being fascinated with engineering, having an interest in math, and science, and having a thirst for engineering knowledge. Five items borrowed from Sheppard et al. (2010) were used to confirm this construct with a reliability coefficient of $\alpha = 0.74$. Integrated finding 4 is consistent with Sheppard et al. (2010); they found that senior underrepresented minority students were more psychologically motivated to study engineering than non-underrepresented minority students. Having an interest in or being good at math and science as reasons to pursue engineering have also been found previously for all students (Fleming, Smith, Chivon, Williams, & Bliss, 2013; Pierrakos, Beam, Constantz, Johri, & Anderson, 2009; Pierrakos, Beam, Watson, Thompson, & Anderson, 2010).

Integrated Finding 5: Students reported that professional and leadership skills were important to their development as engineers. Specifically, students mentioned non-technical communication and networking skills and the ability to taken on leadership roles within SHPE. The construct of developing as a professional and a leader was confirmed through exploratory factor analysis using nine items with a reliability coefficient of $\alpha = 0.94$. The finding regarding the importance placed on acquisition of professional skills is consistent with the literature. Sheppard et al. (2010) found that underrepresented minority senior students valued professional interpersonal skills more than non-underrepresented minority students. Similarly, in their profile of an engineer, Davis, Beyerlin, and Davis (2005) highlighted specific essential professional interpersonal skills for engineers such as being a communicator and a collaborator. Developing leadership skills has not been addressed in other studies of engineering identity (Fleming, Smith, Williams, & Bliss, 2013; Hughes & Hurtado, 2013; Meyers, Ohland, Pawley, Silliman, & Smith, 2012; Tonso, 2006) though this dimension was included in the profile of an engineer of David, Beyerlin, and Davis (2005).

Integrated Finding 6: Having a commitment to the community played an important role in the students' engineering journeys. The commitment to the community construct was confirmed through exploratory factor analysis using five items with a reliability coefficient of α

= 0.77. More important, students acted on their commitment to the community through community service and outreach to kids, especially through STEM outreach programs organized with SHPE. Research has shown that Latina/o students in higher education place an importance on being committed to the community (Perez, 2009; Pérez, 2012; Solórzano & Delgado Bernal, 2001; Yosso, Smith, Ceja, & Solórzano, 2009). However, this dimension to engineering identity has not been previously studied or addressed. In an intervention for students of color, Omar, Sampson, and Lee (1999) found that after attending a SHPE national conference students had a desire to become role models or mentors to fellow students. Sheppard et al. (2010) showed that underrepresented minority women and men seniors are more motivated by social good to pursue engineering than their non-minority counterparts. Yet, as an example, the profile of an engineer, as developed using Accreditation Board for Engineering and Technology (ABET) criteria by Davis, Beyerlin, and Davis (2005), does not include aspects of social responsibility or commitment to community.

Integrated Finding 7: Being and finding engineering role models was an important dimension of students' engineering identity development. For the interviewed students, being an engineering role model and mentor to other engineering students was critical in their development as engineers. Some of the students expressed this idea as "paying it forward" or realizing that succeeding in engineering is not just an individual achievement. It follows then that students also wanted engineering role models, especially within SHPE. Finding an engineering role model was confirmed with exploratory factor analysis using three items with an alpha reliability coefficient of $\alpha = 0.75$. While the items asking about being (rather than finding) engineering role models did not load with the engineering role modeling construct, overall students rated these items high. The importance of engineering role models for the success of students of color in engineering has been documented in the literature (Griffin, Pérez, Holmes, & Mayo, 2010; Omer, Sampson, & Lee, 1999; Ong, Wright, Espinosa, & Orfield, 2011; Tsui, 2007). However, the importance of engineering role modeling (being and having) has not been previously integrated into conceptualization of engineering identity development.

Integrated Finding 8: Belonging to an engineering *familia* (family or kin) supported students' engineering identity development. Students described being part of a *familia* as being part of "people who look like me," brothers and sisters who want to see each other succeed, a huge network of Latina/o engineers, and family who is there through the good and the bad. For the most part, SHPE provided the *familia* aspect in engineering for students. While having no bloodline connection to others in SHPE, students felt connected to them as if they were *familia*. This construct, engineering *familia*, was confirmed through exploratory factor analysis using four items with a reliability coefficient of $\alpha = 0.85$. Fordham and Ogbu (1986) found that fictive kinship was a symbol of collective social identity for black Americans. Black American high school students also used words like "brothers" and "sisters" to refer to one another and to denote membership in the fictive kinship.

The importance of feeling a sense of belonging and having a STEM community has been documented for the success students of color in higher education (Foor, Walden, & Trytten, 2007; Griffin, Pérez, Holmes, & Mayo, 2010; Museus, & Liverman, 2010; Ong, Wright, Espinosa, & Orfield, 2011; Tsui, 2007). Hurtado and Carter (1997) found that being part of social-community organizations was strongly associated with Latina/o students feeling a sense of belonging. In engineering, some have recommended the clustering of students into peer groups to address retention and persistence of students of color (Martin, Simmons, & Yu, 2013; May & Chubin, 2003). The importance of being recognized as an engineer by others in engineering has been documented for the development of an engineering or science identity (Carlone & Johnson, 2007; Stevens, O'Connor, Garrison, Jocuns, & Amos, 2008; Tonso, 2006). However, these findings suggest that it is not only important to be identified as engineers by others, but it is also important that those others are also part of one's engineering *familia*.

Integrated findings 5, 6, 7, and 8 confirm findings from Sedlacek's (2004) noncognitive assessment model of students of color. The model has eight noncognitive variables that are particularly important for the success of students of color. These variables are positive self-concept, realistic self-appraisal, successfully handling the system, preference for long-term goals, availability of strong support person, leadership experience, community involvement, and knowledge acquired in the field. The findings from this study are consistent with at least three of these variables. First, Sedlacek found that students who had leadership skills were more likely to succeed in college than those who did not have leadership skills. Integrated finding 5 in this study showed that developing leadership skills was an important aspect of developing as an engineer. Second, Sedlacek found that students who had a strong support person especially during challenging times performed well in school. This noncognitive assessment variable is consistent with integrated findings 7 and 8. Third, Sedlacek found that students who were involved in the community and had a community with which they identified were more successful than students who were not involved. Integrated finding 6 in this study also showed the importance of being involved in and committed to the community as an important aspect of developing an engineering identity.

Conceptual Framework

Previous studies of engineering identity that have studied the topic from the student perspective have focused on the experience of the aggregated population of engineering students, often ignoring differences for underrepresented students. Using Yosso's Community Cultural Wealth framework, I examined the engineering journeys of Latina/o students. Specifically, I identified ways in which students use their aspirational, familial, social, navigational, and resistant capitals to develop as engineers. Figure 6.1, also presented in Chapter 4, shows the connection between the findings from this study and the framework used to analyze the data.

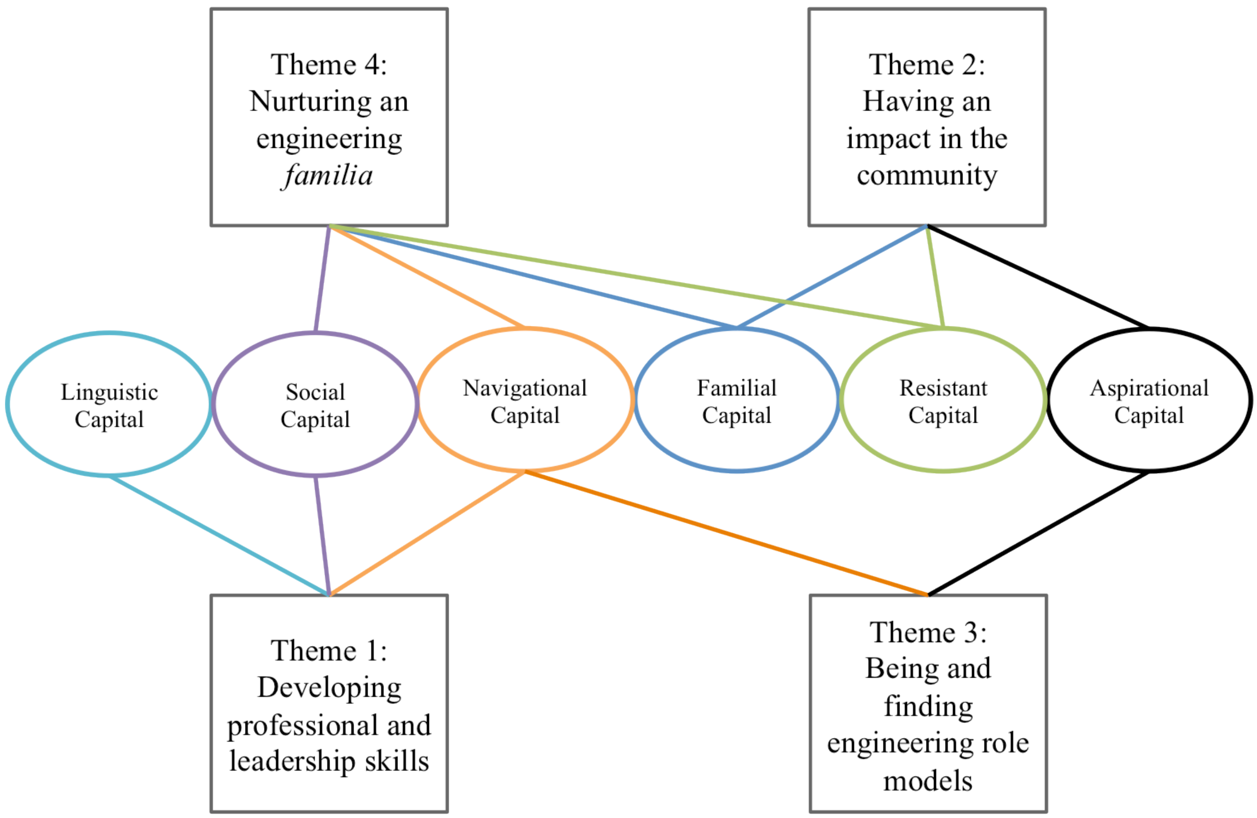

Figure 6.1 – Community Cultural Wealth Applied to Findings

With familial capital, students nurture their SHPE *familia* and stay committed through the well being of the community. Family or kin is understood to include not just immediate family, but also friends and extended family. Similar to the findings of Delgado Bernal (2002), I found that the students maintained a commitment to the well being of the community through their community outreach, especially with middle and high school students, and their community service. The students also stayed committed to each other's success and treated as each other as family. As has been found elsewhere with Latina/o college students (Hernandez, 2002), the students' conceptualization of family included other people in SHPE to whom, prior to joining the organization, the students had no relationship. Finally, whereas in the literature being an engineer is usually equated with individualistic success, these students viewed being and becoming an engineer with a collectivistic perspective. In other words, being or becoming an engineer was not just about one's success, but it was also about the success of the group. In this case, that group success would include peers in SHPE, but it could also include the success of other Latina/o engineers and the community at large. In his study of Latino *logradores* (high-achievers), Pérez (2012) found that the students "invested a considerable amount of time in co-curricular activities that presented them with opportunities to give back to their communities and peers at-large" (p. 115).

With navigational and social capital, students are able to navigate the engineering field, climate, and profession through their involvement with SHPE. SHPE can be understood as a form of counterspace. Counterspaces "serve as sites where deficit notions of people of color can be challenged and where a positive collegiate racial climate can be established and maintained" (Solórzano, Ceja, & Yosso, 2000, p. 70). Within these counterspaces, Latina/o students can build a sense of community that represents the cultural wealth of their home communities (Yosso, Smith, Ceja, & Solórzano, 2009). The SHPE *familia* serves as a social and academic counterspace for students. This study also shows that SHPE serves as a professional counterspace for students. SHPE serves a professional counterspace for students in that within SHPE being Latina/o is congruent to being an engineer. For the majority of these students, especially those who attend Predominantly or Traditionally White Institutions, being Latina/o may not always be considered congruent with being an engineer.

With aspirational capital, students maintained their high hopes and dreams through having engineering role models within SHPE. This finding challenges the idea that ethnic enclaves decrease social integration for students of color (Person & Rosenbaum, 2006). Instead, by finding and having engineering role models within SHPE, students interacted with people who look like them and through whose stories they aspired to achieve and succeed.

Finally, with resistant capital, students showed forms of resistant capital by resisting stereotypes and taking on their engineering journey and inspiring other Latina/o students to do the same. The type of resistance that the students showed is likely not a form of transformative resistance (Solórzano & Delgado Bernal, 2001), where a student "demonstrates both a critique of oppression and a desire for social justice" (p. 319). Rather interviewed students showed a combination of conformist and transformative resistance. The students had a critique of oppression, for some of them at least somewhat of an understanding of this oppression, but they did not challenge it individually. In other words, they were "working within the existing social systems and social conventions" (p. 318). Although the students did not express a transformative form of resistance, they still acted as resistors and employed their resistant capital by persisting in their engineering journey through their involvement in SHPE. Through their involvement, they made the decision to use SHPE's resources to develop their professional and leadership skills. In their community outreach and service, they were driven by a mission to promote a college-going culture for the success for the Latina/o community.

Although students did not call themselves activists or discuss resisting oppression individually, they manifested their resistant capital through a collective form of resistance. Through their pursuit of SHPE's mission and the pursuit to better STEM access and awareness for Latina/o students, the students, as a group, resisted by working towards a positive change in engineering for themselves and their communities.

The Community Cultural Wealth framework provides an asset-based approach to the conceptualization of engineering identity development. Through an asset-based approach, I focused on the knowledges and experiences of the students' engineering journeys and identity development rather than their deficiencies. Harper (2010) argues that "an anti-deficit inquiry recognizes students of color as experts on their experiential realities and empowers them to offer counternarratives concerning their success in STEM fields" (p. 71). Consistent with Harper (2010), through the use of the Community Cultural Wealth framework, this study approached engineering identity development from the student experiential realities. Their experiential realities were further examined through a lens of capital that these students possess and use in their engineering journeys. As such, this study reframes the study of engineering identity not just to understand development of engineering identity from the students' perspectives, but also to culturally situate development of engineering identity.

Implications

Implications for Research

The dimensions of engineering identity development uncovered through the use of the Community Cultural Wealth framework suggest that future studies of engineering identity development may benefit from frameworks that encourage a culturally situated understanding of the population under study. The Community Cultural Wealth framework was created to acknowledge and celebrate the various capitals and wealth that people of color have. The use of these types of frameworks can enable researchers to obtain a deeper understanding of the nuanced experiences of diverse and underrepresented groups of students in engineering.

Although the Community Cultural Wealth framework that guided this study revealed important dimensions of engineering identity development for Latina/o undergraduates, the use of this framework did not uncover differences of experiences within this group. As an example, gender differences in engineering and science identity development exist (Carlone & Johnson, 2007; Meyers, Ohland, Pawley, Silliman, & Smith, 2012; Tate & Linn, 2005) and may be most salient in engineering where women from underrepresented racial and ethnic groups are especially underrepresented. In the future, engineering education researchers should explicitly investigate gender differences when using frameworks that may not inherently reveal these differences. In addition, other differences across social identities may be salient for this and other student populations. Nuñez (2014) proposed a framework for Latina/o college students that incorporates intersectionality and a model of multiple dimensions of identity to address college success. Such a framework may be important, especially for Latina/o students, to uncover within group differences in engineering identity development.

Implications for Policy

The central role that SHPE played in students' engineering identity development illustrates the importance of providing these spaces for students in engineering. The space that SHPE created for Latina/o students to develop as engineers can be understood as an academic and social counterspace. Counterspaces can be especially important for students of color in engineering because they represent a connection to the cultural wealth of their home communities (Yosso, Smith, Ceja, & Solórzano, 2009). This connection may be difficult to establish outside of these counterspaces because students are underrepresented in engineering. Administrators and faculty can support students in the creation of these counterspaces. As an example, colleges and programs of engineering may allocate office space for organizations like

SHPE. Changes to institutional policy can address sustainable ways that resources are allocated to counterspaces, such as SHPE. Baber (2015) found that programmatic efforts to promote diversity and equity in STEM programs were funded by non-recurring funds. In their support of organizations like SHPE and counterspaces for engineering students, administrators and faculty are supporting the way that students develop as engineers. Further, with allocation of resources and a physical space (such as office space) for counterspaces like SHPE, SHPE can become a place, rather than only a space (Baber, 2010). Baber describes the shift from space to place as "critical to traditional notions of cultural dominance and exclusion at PWIs" (p. 223). As a place, SHPE can address support equity for Latina/o students in engineering programs.

The strong bonds students had with one another (engineering *familia* and engineering role modeling) and with their community (commitment to the community) suggest that these dimensions of identity can be further fostered in the classroom. Inclusion of these dimensions of identity in curriculum development and pedagogy could strengthen engineering identity development for students. For example, service-learning courses in engineering in which one of the primary components is volunteering in the community. Also as an example, there have been minors, and courses in engineering, created to address the need for acquisition of leadership skills toward development as an engineer (Seat, Parsons, & Poppen, 2001).Though these dimensions of identity may be currently met through involvement in SHPE, they can be validated and sustained in the classroom so that students can have an integrated engineering identity development. In other words, if the goal of engineering education is to develop students as engineers, then these dimensions of engineering identity development should also be integrated into the classroom.

Future Research

There are at least three ways in which future research can enrich this study and its implications. First, the survey of engineering identity could be distributed more widely. The sample used for factor analysis was limited in size; a future distribution of this survey can target a larger sample for a richer analysis. The first step in a future distribution of the survey would be in using confirmatory factor analysis to confirm the constructs explored in this study. Also important, data from a wider distribution of this survey could used to analyze within-group relationships of engineering identity development. As an example, researchers could investigate differences in gender, school-type, major, and college generation status. This investigation would provide a nuanced understanding of Latina/o engineering students and their engineering identity development. Second, although this study looked at SHPE students who self-identified as Latina/o, future expansion of the survey can be achieved by incorporating non-SHPE or non-Latina/o students in the sample. Doing so can address research questions that compare the impact of SHPE on Latina/o students with the impact on non-Latina/o students. Third, this study shows the importance of counterspaces in engineering and their role in the development of students' engineering identities. Future studies could investigate the existence of other counterspaces for students of color in engineering and how these support identity development.

Conclusion

The issue of underrepresentation of Latina/o undergraduates in engineering motivated this study of engineering identity development. The purpose of this mixed methods study was to develop an engineering identity survey that was grounded in the engineering journeys of Latina/o undergraduates using an asset-based approach. This study answered the following research question: In what ways and to what extent does membership in the Society of Hispanic Professional Engineers influence the engineering identity development of Latina/o students?

Findings from this study about Latina/o students' pre-college educational journeys and established engineering identities confirmed many previous findings (Brown, 2002; Chanderbhan-Forde, Heppner, & Borman, 2012; Chapa & De La Rosa, 2006; Mannon & Schreuders, 2007; May & Chubin, 2003; Villenas & Deyhle, 1999). However, there were notable differences. First, most students considered themselves engineers even when they did not yet have an engineering degree. Second, female students were just as likely to identify as engineers (or engineers in training) than male students. The latter suggests important considerations for future studies of within group experiences for Latina/o students in engineering. This study also confirmed the importance of professional and leadership skills in the development as an engineer (Davis, Beyerlin, & Davis, 2005; Sheppard et al., 2010). This study provided additional evidence for the saliency of acquiring leadership skills for Latina/o students. The saliency of acquiring leadership skills has not been addressed in previous studies of engineering identity development, though it has been addressed in studies of success of students of color in higher education (Sedlacek, 2004).

This study contributes to the literature on engineering identity by presenting three new dimensions of engineering identity development for Latina/o students. These dimensions were commitment to community, engineering role modeling, and nurturing an engineering *familia*. These additional dimensions should be considered in future conceptualization of engineering identity development for Latina/o students. They tell of a communitarian and collectivist engineering student. A communitarian engineer, as informed by the commitment to community and nurturing an engineering *familia* dimensions, is motivated not just by the social good and social responsibility of doing engineering, but also by the direct commitment he or she has for the well being of the community. A communitarian engineer acts upon his or her commitment through community outreach and service. Similarly a collectivist engineer, as informed by the engineering role modeling and engineering *famila* dimensions, is concerned with more than his or her individual success in engineering. A collectivist engineer is concerned with and driven by the success of the group, not only his or her individual success.

Finally, the findings from this study show that SHPE served as an academic, social, and professional counterspace for students' engineering identity development. However, in order for students to have an integrated way of developing their engineering identity, the students' dimensions of engineering identity development found in this study must also be supported outside of this counterspace. In other words, counterspaces should not be the only spaces where students are able to grow and develop as engineers. To continue to address retention of Latina/o students in engineering, we must broaden the way we support these students in their development as engineers inside and outside the engineering classroom.

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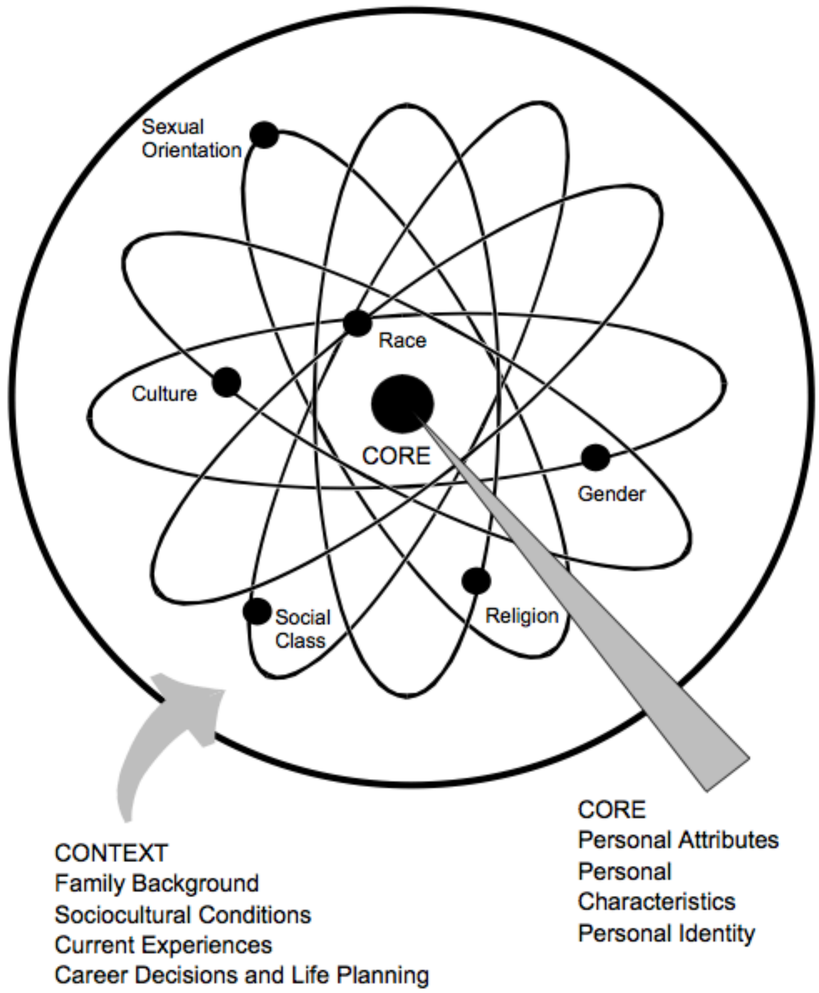
Appendix A

Model of multiple dimensions of identity by Abes, Jones, McEwen (2007)



Appendix B

------Start of Interview-----
Thank you for volunteering your time and allowing me to ask you some questions about your story as a Latina/o engineering student and a SHPE member at your university. Please remember that there no right or wrong answers and I want to hear about your experiences.

1. With this in mind, would you please tell me a little bit about yourself?
2. What university do you currently attend?
   Probes:
   a. Ask about major
   b. Ask about year in school
   c. Ask about any other previous majors
   d. Ask about any previous community colleges or universities
3. In reference to attending college, what would you say your generational status is?
   Probe:
   a. Did your grandparents, parents, and/or siblings attend college?
4. How would you describe your race?
5. How would you describe your ethnicity?
   Probe to questions 2 or 3:
   a. How would you describe your generational status for [Latino/a or other]?
6. What language (or languages) did you speak growing up?
7. What role, if any, does this language have in your journey to college for you?
8. Are there other ways of identifying yourself that are significant to you that you feel comfortable discussing with me?

Okay, great. Thank you. Now, I would like to ask you about your journey to college and specifically engineering.

9. We often hear about one's journey to college, how did I get here?, can you discuss what your journey to college was like?
   Follow up questions:
   - How did you choose engineering as a major?
   - Was the journey towards engineering different than the journey to college?
   Probe question:
   a. What was the role your parents, guardians, or other people played in this journey?
   b. Before you entered college, did you know any [other] engineers? Were your parents engineers?

Thank you, so you're pursuing an engineering degree and I have some questions about how you consider yourself an engineer. Some researchers call this "engineering identity"

10. Would you consider yourself an engineer (or an aspiring engineer)?
    Follow up question:
    - Can you describe what it means for you to be or aspire to be an engineer?

11. How would you describe your journey as an engineer (or aspiring engineer, engineering student)? (*Ask one or other based on answer to question #10*)

Thank you for sharing your story, now I'll ask you some questions about your SHPE membership.

12. How long have you been a SHPE member?
    Probe questions:
    a. National SHPE member and/or chapter member
13. How has your experience as a member of SHPE been like? (*Make sure to distinguish from national or chapter membership if they are referring to both*)
14. Can you tell me one or more of your memorable experiences from your involvement with SHPE?
15. How has your involvement with SHPE changed (or not) over the years?
16. What role has SHPE played in your journey as an engineering student, aspiring engineer, and/or engineer?
17. How would you describe SHPE to other engineering students who may want to join?

Finally, I'll ask you some questions generally about your journey pursuing an engineering degree at your university.

18. What does your support system(s) look like to an outsider?
    Probe question:
    a. Is your "family" part of this support system? If so, how would you describe your "family"?
        i. Any siblings? Younger, older.
19. Can you describe the interactions that you have had with your support group(s) that have helped you continue in engineering?
20. Have you been away from home since starting your engineering major at your university?
    Follow up question:
    a. What has that experience been like for you?
21. If you could change anything about your experience as an engineering student in the university, what would it be?
    Probe:
    a. How and why would you change it?
22. What difficulties or barriers have you faced in this journey towards your engineering degree?
    Follow up question:
    a. How have you dealt with those (barriers)?
23. What people or resources have been beneficial to your success in engineering?
24. Finally, is there anything else you would like to add with regard to what we have discussed in this interview?

Appendix C

Table C.1

Interview Questions Matched to Forms of Capital

		Forms of Capital					
	Question Number	Aspirational	Familial	Linguistic	Navigational	Resistant	Social
What language (or languages) did you speak growing up?	Q6			X			
What role does language have in this pathway for you?	Q7			X			
We often hear about one's journey to college, how did I get here?, can you discuss what your journey to college was like?	Q9	X					
What was the role your parents, guardians, or other people played in this journey?	Q9a	X					
How would you describe your journey as an engineer?	Q11				X	X	
How has your experience as a member of SHPE been like?	Q13						X
Can you tell me one or more memorable experiences of your involvement in SHPE?	Q14						X
What role has SHPE played in your journey as an engineering student, aspiring engineer, and/or engineer?	Q16				X		X

Table C.1 (cont.)

	Question Number	Aspirational	Familial	Linguistic	Navigational	Resistant	Social
How would you describe SHPE to other engineering students that may want to join?	Q17						X
What does your support system(s) look like to an outsider?	Q18		X				X
Is your “family” part of this support system? If so, how would you describe your “family”?	Q18a		X				
Can you describe the interactions that you have had with your support group(s) that have helped you continue in engineering?	Q19				X		X
Have you been away from home since starting your engineering major at your university? What has that experience been like for you?	Q20		X				
If you could change anything about your experience as an engineering student in the university, what would it be? How and why would you change it?	Q21					X	
What difficulties or barriers have you faced in this journey towards your engineering degree?	Q22				X	X	
What people or resources have been beneficial towards your success in engineering?	Q23				X		X

Appendix D

Themes presented to participants during member checks

1. SHPE has had a role in the participants' journey as engineers in the following ways:

    a. By gaining professional and leadership skills available through workshops, the national SHPE conference, and other SHPE-related activities (NILA, connection to SHPE professional chapters, regional conferences)
    b. By being able to "get a job" through the career fairs and by gaining the professional and leadership skills available through SHPE
    c. Through giving back to the community, mostly through outreach to kids, but also other forms of community service
    d. By helping participants realize to "pay it forward" by being an influence, role model, or a mentor to younger engineering students or engineers-to-be
    e. By providing an "encouraging" and supportive space where participants are able to find other students in similar journeys and who are "more like" them culturally. Many participants conceptualized this space as being part of a SHPE *familia* and having a "home away from home"
    f. By providing ways for participants to find engineering role models, some of these local to their campus or alumni, and some at the national conference

2. Most participants mentioned the university resources available to them, yet they opted to use the resources that SHPE offered to them. These resources were there for academic, professional, and leadership development.
3. Some participants discussed instances where they emphasized to others, while recruiting students or recounting their experiences in SHPE, that SHPE is not just for Hispanics or Latinas/os or Engineers.

Appendix E

Appendix E shows the survey used for cognitive interviews. Each gray band shows the separation between web pages.

1. Which of these statements best describes you? ***(Check all that apply)***

- ☐ I consider myself an engineer
- ☐ I do not consider myself an engineer
- ☐ I consider myself a scientist
- ☐ I consider myself an aspiring engineer or an engineer in-training

Your engineering journey

2. How good do you feel when you are doing engineering?

- ○ Extremely good
- ○ Very good
- ○ Moderately good
- ○ Slightly good
- ○ Not at all good

Your engineering journey

3. How fun do you think engineering is?

- ○ Extremely fun
- ○ Very fun
- ○ Moderately fun
- ○ Slightly fun
- ○ Not at all fun

Your engineering journey

4. How interesting do you think engineering is?

- ○ Extremely interesting
- ○ Very interesting
- ○ Moderately interesting
- ○ Slightly interesting
- ○ Not at all interesting

Your engineering journey

5. To what extent do you like to build stuff?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

6. How important is giving back to the community through outreach such as Noche de Ciencias (Science Night) to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

7. How important are STEM outreach programs for kids to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

8. As an engineer, how important is being involved in your community to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

9. As an engineer, how committed are you to the well being of your community?

- Extremely committed
- Very committed
- Moderately committed
- Slightly committed
- Not at all committed

Your engineering journey

10. To what extent has SHPE helped you develop as a professional?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

11. To what extent have you acquired non-technical, professional skills from SHPE that you need to become an engineer?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

12. To what extent have you attended SHPE workshops to learn about non-technical, professional skills that you need to become an engineer?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

13. To what extent have you developed your non-technical, professional skills through your SHPE involvement?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

14. To what extent have you developed communication skills to network with other professionals through SHPE?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

15. To what extent has SHPE helped you develop as a leader?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

16. As an engineer, how important is developing as a leader to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

17. To what extent have you acquired leadership skills that you need to be an engineer through SHPE?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

18. To what extent have you attended SHPE workshops to learn about leadership skills that you need to be an engineer?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

19. To what extent have you been <u>able</u> to take on leadership roles in SHPE that you need to be an engineer?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

20. In your journey as an engineer, how important is finding engineering role models <u>within SHPE</u> to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

21. In your journey as an engineer, how important is finding engineering role models to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

22. In your journey as an engineer, how important is being an engineering role model to other engineering students to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

23. In your journey as an engineer, how important is being an engineering role model to younger students to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

24. In your journey as an engineer, how important is helping other engineering students prosper?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

25. In your journey as an engineer, how important is having an engineer role model to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

26. In your journey as an engineer, how important is to have younger engineering students look up to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

27. To what extent do you look for engineering role models in SHPE?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

28. To what extent do you feel like you have a *familia* (family) of engineers within SHPE?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

29. To what extent are you recognized as an engineer within SHPE?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

30. How important is to have a SHPE *familia* (family) of engineers to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

31. How important is to have support from other engineers who look like you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

32. To what extent do you feel like you are part of a *familia* (family) when you are around Latina and Latino engineers?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

33. To what extent does seeing other engineers who look like you make you feel like you can succeed in engineering?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Before college

34. Did you know any engineers <u>before</u> starting college?

- Yes
- No

35. How did you know these engineers? ***(Check all that apply)***

- ☐ My mother is an engineer
- ☐ My father is an engineer
- ☐ My guardian is an engineer
- ☐ My sibling(s) is an engineer
- ☐ Other family members are engineers
- ☐ Other (please specify)

36. I met other engineers through... (Check all that apply)

- ☐ High School teacher
- ☐ High School counselor
- ☐ High School friends
- ☐ Other(s) (please specify)

37. Before college, I was... ***(Check all that apply)***

- ☐ Involved in an academic STEM program *(e.g., summer program, after-school program, etc.)*
- ☐ Involved in an extracurricular engineering program *(e.g., summer program, after-school program, etc.)*
- ☐ Shadowed an engineer
- ☐ Took engineering high school courses
- ☐ Took computer science high school courses
- ☐ None of the above

38. What university do you currently attend?

39. Did you transfer to your current institution from a different college or university?

- ○ Yes
- ○ No

40. What is your current major? ***(e.g., Aerospace Engineering, Electrical Engineering)***

41. What year are you in your undergraduate program?

- ○ 1st year
- ○ 2nd year
- ○ 3rd year
- ○ 4th year
- ○ 5th year
- ○ 6 or more years

Your SHPE involvement

42. How many years have you been involved with SHPE?

- ○ Less than 1 year
- ○ 1 to 2 years
- ○ 3 to 4 years
- ○ More than 4 years

43. What roles have you held in SHPE? ***Check all that apply***

- ☐ General Member
- ☐ Executive Board Member
- ☐ Jr. SHPE Member
- ☐ National Representative

Demographics

44. What is your gender?

45. What is your age?

46. Do you identify as Chicana/o, Hispanic, or Latina/o?

- ○ Yes
- ○ No
- ○ Sometimes
- ○ Not sure

47. What is your ethnic background? ***(Check all that apply)***

- ☐ Argentinean
- ☐ Bolivian
- ☐ Chilean
- ☐ Colombian
- ☐ Costa Rican
- ☐ Cuban
- ☐ Dominican
- ☐ Ecuadorian
- ☐ Guatemalan
- ☐ Honduran
- ☐ Mexican
- ☐ Nicaraguan
- ☐ Panamanian
- ☐ Paraguayan
- ☐ Peruvian
- ☐ Puerto Rican
- ☐ Salvadorian
- ☐ Uruguayan
- ☐ Venezuelan
- ☐ Other (please specify)

48. What is the highest level of education achieved by your parents or guardians?

- Not Applicable or Unknown
- Elementary school
- Middle school
- Some high school
- High school diploma or G.E.D.
- Some college
- Business/technical certificate
- Associates degree
- Bachelor's degree
- Some graduate school
- Master's degree
- Doctoral degree *(Ph.D., Ed.D., etc.)*
- Professional degree *(i.e. MBA, JD, etc.)*

Appendix F

Appendix F shows the changes made to survey using feedback from cognitive interviews

I conducted two cognitive interviews with potential survey takers who were content area experts. Both of these students were engineering undergraduates and members of SHPE at the time of the cognitive interview. I asked the students to complete the survey as if they were actually taking it. I provided the students with a copy of the survey to take notes on. The students took the web survey on a computer. After they were finished, I asked the students to retroactively think about the questions and point out anything that seemed off, focusing on the wording and formatting. One of the students took 10 minutes to complete the survey; the other student took 17 minutes to complete the survey. Immediately after they took the survey, I asked them “How long did the survey feel?” Both of them answered that the survey “didn’t feel long.” Below is the question-by-question feedback and changes that were made based on the cognitive interviews. There was no feedback or comments on the omitted questions.

Question 2: One of the students was unsure about what I meant by “doing engineering.” He thought about “all the phases” or aspects of doing engineering, he mentioned: course work and internships. His recommendation was to add “In general,” or “Overall” to the question. To address this and other comments about questions about what I mean by engineering journey, I added the following sentence prior to question #6 to prompt the students to think about their engineering journeys to include everything that they would consider part of them becoming an engineer: “For the next set of questions, please think about your <u>overall</u> journey in engineering so far.”

Questions 7, 23, & 26: Both students mentioned the awkward and redundant phrasing of these questions. They suggested to get rid of the “to you” and re-word accordingly to make the question more clear. As a result of the students’ recommendations, the questions were reworded for clarity.

Question 19: One of the students wondered if the question was asking about the ability to take on the leadership role or how many leadership roles one has taken. The question was supposed to be asking about ability to take on leadership roles. As a result of this comment and as suggested by the student, I underlined the word “able” in the item.

Question 20: One of the students was meant by “in your journey as an engineer.” When prompted with this question, he thought about himself as a professional engineer, as an undergraduate engineer, or as a graduate engineer. The student had no recommendations for this item. As a result of this comment, along with other comments about what is meant by “engineer”, I added the prompt before Question #6 so that students would know what I mean by “journey as an engineer.”

Question 29: Both students thought the wording of this sentence and the use of the verb “recognize” was awkward. Because recognition is an important aspect of science and engineering identity, I did not get rid of the word. Instead, I reworded the question to get the concept across. I used one of the student’s recommendation, which was to reword the question so that it was more explicit that the recognition was coming from peers within SHPE.

Questions 31 & 33: One of the students thought that “look like you” as part of the question sounded “judgy.” As she was trying to answer this question, she thought about the people from her racially and ethnically diverse SHPE chapter. The “look like you” verbiage comes from the first phase of the study where students mentioned the importance of having others who look like them, in terms of being a Latina/o. To maintain that sentiment, but make it more clear for the survey, I changed “look like you” to “Latina/o.”

Question 37: One of the students recommended adding the answer option of “Knew about engineering.” He mentioned that before college he did not know what engineering was. I added his suggestion as an answer option as this comment was also reflected in the way interviewed students talked about their pre-college experiences with engineering.

Appendix G

Appendix G shows the final web survey distributed using SurveyMonkey.

Engineering Survey

Consent Form

Dear Fellow SHPE Member,

Thank you for taking part of an important research investigation about your experience as an undergraduate student member of SHPE. We hope you will offer us your honest and thoughtful opinions while taking this survey.

We expect the survey will take you about 15 minutes to complete, and we expect no risk posed to you by completing this survey other than what you might experience in everyday life. The information gathered from the survey will be part of my dissertation work towards my Ph.D. degree at the University of Illinois at Urbana-Champaign. This survey is to be completed anonymously; no individually identifying information will be reported.

Questions about this research (IRB #14076) should be directed to Professor Lorenzo Baber (phone 217 333-1576, e-mail ldbaber@illinois.edu), Professor Michael Loui (phone 217 333 2595, email loui@illinois.edu) or Renata A. Revelo Alonso (phone 847-899-7369, e-mail revelo@illinois.edu). If you have any questions about your rights as a research participant in this study, please contact the University of Illinois Institutional Review Board at 217-333-2670 (collect calls accepted if you identify yourself as a research participant) or via email at irb@illinois.edu.

To **consent to participate** in this important research study, click the **NEXT** button below to start the survey. You may print this page for your records.

Many thanks for your participation!

Renata A. Revelo Alonso
Ph.D. Candidate
Department of Education Policy, Organization, and Leadership
University of Illinois at Urbana-Champaign

1. What university do you currently attend?

2. Did you transfer to your current institution from a different college or university?

- Yes
- No

3. What year are you in your undergraduate program?

- 1st year
- 2nd year
- 3rd year
- 4th year
- 5th year
- 6 or more years

Engineering Survey

4. What is your current major(s)? ***Check all that apply***

- ☐ Aerospace engineering
- ☐ Architectural engineering
- ☐ Bioengineering
- ☐ Chemical engineering
- ☐ Civil engineering
- ☐ Computer engineering
- ☐ Computer science
- ☐ Electrical engineering
- ☐ Engineering mechanics
- ☐ Enviornmental engineering
- ☐ Industrial engineering
- ☐ Manufacturing engineering
- ☐ Materials engineering
- ☐ Mechanical engineering
- ☐ Nuclear engineering
- ☐ Other (please specify)

5. Which of these statements best describes you? ***Check all that apply***

- ☐ I consider myself an engineer
- ☐ I consider myself an aspiring engineer or an engineer in-training
- ☐ I consider myself a scientist
- ☐ I do not consider myself an engineer

Your engineering journey

Engineering Survey

For the next set of questions, please think about your overall journey in engineering so far.

Your engineering journey

6. How good do you feel when you are doing engineering?

- ○ Extremely good
- ○ Very good
- ○ Moderately good
- ○ Slightly good
- ○ Not at all good

Your engineering journey

7. How fun do you think engineering is?

- ○ Extremely fun
- ○ Very fun
- ○ Moderately fun
- ○ Slightly fun
- ○ Not at all fun

Your engineering journey

8. How interesting do you think engineering is?

- ○ Extremely interesting
- ○ Very interesting
- ○ Moderately interesting
- ○ Slightly interesting
- ○ Not at all interesting

Your engineering journey

Engineering Survey

9. To what extent do you like to build stuff?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

10. To what extent do you like to figure out how things work?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

11. As an engineer, how important is giving back to the community through outreach such as Noche de Ciencias (Science Night)?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

Engineering Survey

12. To you, how important are STEM outreach programs for kids?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

13. As an engineer, how important is being involved in your community to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

14. As an engineer, how committed are you to the well being of your community?

- Extremely committed
- Very committed
- Moderately committed
- Slightly committed
- Not at all committed

Your engineering journey

15. To what extent has your participation in SHPE helped you develop as a professional?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Engineering Survey

Your engineering journey

16. To what extent have you acquired non-technical, professional skills from SHPE that you need to become an engineer?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

17. To what extent have you attended SHPE workshops to learn about non-technical, professional skills that you need to become an engineer?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

18. To what extent have you developed your non-technical, professional skills through your SHPE involvement?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

Engineering Survey

19. To what extent has your participation in SHPE helped you develop communication skills to network with other professionals?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

20. To what extent has your participation in SHPE helped you develop as a leader?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

21. As an engineer, how important is developing as a leader to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

Engineering Survey

22. To what extent has your participation in SHPE helped you acquire leadership skills that you need to be an engineer?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

23. To what extent have you attended SHPE workshops to learn about leadership skills that you need to be an engineer?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

24. To what extent have you been able to take on leadership roles in SHPE that you need to be an engineer?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

Engineering Survey

25. In <u>your journey as an engineer</u>, how important is finding engineering role models <u>within SHPE?</u>

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

26. In <u>your journey as an engineer</u>, how important is being able to find engineering role models?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

27. In <u>your journey as an engineer</u>, how important is being an engineering role model to other engineering students?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

Engineering Survey

28. In <u>your journey as an engineer</u>, how important is being an engineering role model to middle school and high school students?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

29. In <u>your journey as an engineer</u>, how important is helping other engineering students prosper?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

30. In your <u>journey as an engineer</u>, how important is having an engineer role model?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

Engineering Survey

31. How important is it to you to have younger engineering students look up to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

32. To what extent do you look for engineering role models in SHPE?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

33. To what extent do you feel like you have a *familia* (family) of engineers within SHPE?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

34. To what extent do your peers in SHPE recognize you as an engineer?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Engineering Survey

Your engineering journey

35. How important is to have a SHPE *familia* (family) of engineers to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

36. How important is having support from other Latina/o engineers to you?

- Extremely important
- Very important
- Moderately important
- Slightly important
- Not at all important

Your engineering journey

37. To what extent do you feel like you are part of a *familia* (family) when you are around Latina and Latino engineers?

- An extreme extent
- A great extent
- A moderate extent
- A small extent
- Not at all

Your engineering journey

Engineering Survey

38. To what extent does seeing other Latina/o engineers succeed make you feel like you can succeed in engineering?

- ◯ An extreme extent
- ◯ A great extent
- ◯ A moderate extent
- ◯ A small extent
- ◯ Not at all

Before college

39. Did you know any engineers <u>before</u> starting college?

- ◯ Yes
- ◯ No

Before college

40. How did you know these engineers? ***Check all that apply***

- ☐ My mother is an engineer
- ☐ My father is an engineer
- ☐ My guardian is an engineer
- ☐ My sibling(s) is an engineer
- ☐ Other family members are engineers
- ☐ Through my high school teacher
- ☐ Through my high school counselor
- ☐ Other (please specify)

Before college

Engineering Survey

41. <u>Before</u> college, I... ***(Check all that apply)***

- ☐ knew about engineering
- ☐ was involved in an academic STEM program (e.g., summer program, after-school program, etc.)
- ☐ was involved in an extracurricular engineering program (e.g., summer program, after-school program, etc.)
- ☐ shadowed an engineer
- ☐ took engineering courses in high school
- ☐ took computer science courses in high school
- ☐ None of the above

Your SHPE involvement

42. How many years have you been involved in SHPE?

- ○ Less than 1 year
- ○ 1 to 2 years
- ○ 3 to 4 years
- ○ More than 4 years

43. What roles have you held in SHPE? ***Check all that apply***

- ☐ General member
- ☐ Executive board member
- ☐ Freshman executive board member
- ☐ Jr. SHPE member
- ☐ National representative
- ☐ Other (please specify)

Demographics

44. What is your gender?

45. What is your age?

Engineering Survey

46. Do you identify as Chicana/o, Hispanic, or Latina/o?

- ○ Yes
- ○ No
- ○ Sometimes
- ○ Not sure

47. What is your ethnic background? *Check all that apply*

- ☐ Argentinean
- ☐ Bolivian
- ☐ Chilean
- ☐ Colombian
- ☐ Costa Rican
- ☐ Cuban
- ☐ Dominican
- ☐ Ecuadorian
- ☐ Guatemalan
- ☐ Honduran
- ☐ Mexican
- ☐ Nicaraguan
- ☐ Panamanian
- ☐ Paraguayan
- ☐ Peruvian
- ☐ Puerto Rican
- ☐ Salvadorian
- ☐ Uruguayan
- ☐ Venezuelan
- ☐ Other (please specify)

Engineering Survey

48. What is the <u>highest</u> level of education achieved by your <u>parents or guardians</u>?

- ○ Not applicable or unknown
- ○ Elementary school
- ○ Middle school
- ○ Some high school
- ○ High school diploma or G.E.D.
- ○ Some college
- ○ Business/technical certificate
- ○ Associate degree
- ○ Bachelor's degree
- ○ Some graduate school
- ○ Master's degree
- ○ Doctoral degree *(Ph.D., Ed.D., etc.)*
- ○ Professional degree *(MBA, JD, etc.)*